PETROLEUM PROCESSING

VOLUME 2, NUMBER 2 FEBRUARY, 1947

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A. E. KRAFT.....Treasurer
Y. A. KOSKINEN.....Advertising Manager
D. P. THORNTON, Jr.....Assistant Editor
WILLIAM F. BLAND.....Engineering Editor

PUBLICATION OFFICE

Cleveland 13, Ohio.....1213 West 3rd St.
CHerry 7672

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PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
For Fuels, Lubricants and Petrochemicals
REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

COMING MEETINGS

February

24-28, American Society of Testing Materials, Spring meeting and Committee week, Benjamin Franklin Hotel, Philadelphia.

March

17-19, American Society of Lubrication Engineers, National Convention, William Penn Hotel, Pittsburgh.
17-19, American Institute of Mining and Metallurgical Engineers, 75th Annual meeting, Waldorf Astoria, New York City.
22-28, American Society for Metals, Western Metals Congress and Exposition, Civic Auditorium, San Francisco.
24-26, Western Petroleum Refiners Assn., Annual membership meeting, Plaza Hotel, San Antonio.
27-29, American Petroleum Institute, Southwestern District, Blackstone Hotel, Ft. Worth.

April

7-10, National Association of Corrosion Engineers, Convention meeting, Palmer House, Chicago.
9-11, Society of Automotive Engineers, Aeronautic meeting, Hotel New Yorker, N. Y.
14-18, American Chemical Society, 111th National meeting, Atlantic City, N. J.
23-25, Natural Gasoline Association of America, 26th Annual convention, Baker Hotel, Dallas.
30-May 2, American Gas Association, Spring meeting, Stevens Hotel, Chicago.

May

12-17, South American Petroleum Council, Lima, Peru.
17-24, International Petroleum Exposition, Tulsa.

June

15-20, American Society of Mechanical Engineers, Annual meeting, Chicago.
16-20, American Society for Testing Materials, 15th Annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

THIS MONTH'S COVER . . .

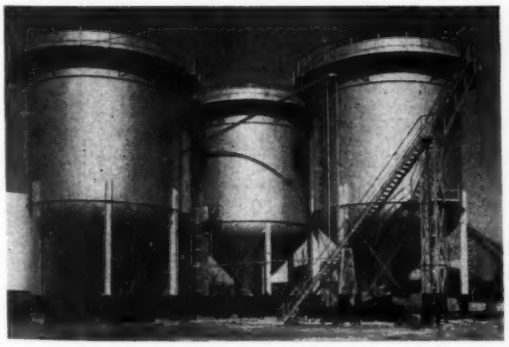

Photo Courtesy Chicago Bridge & Iron Co.

An effective and inexpensive means of solving one refinery's problem of how to dispose of oil-containing-silt involves the use of these three 4000-bbl., cone bottom, silt tanks. Installed at the Baton Rouge refinery of Standard Oil Co. of N. J., they are part of a unit designed by Standard's engineers. The silt is aerated to promote separation of the oil, which rises to the top and is removed. Details on the unit appear in this issue of PETROLEUM PROCESSING, pg. 102

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A Staff Review . . .
PETROLEUM PROCESSING
FEBRUARY, 1947

Bureau of Mines Asks $30,000,000 More For Synthetic Liquid Fuels Research

Would Put Increased Emphasis on Fischer-Tropsch Method, Even Though Oil Companies Are Already Building Two Commercial Plants Using That Process

By WILLIAM F. BLAND
Engineering Editor
and WILLIAM C. UHL
Staff Writer
PETROLEUM PROCESSING

EVEN while private industry through its own research efforts has progressed to the stage of actually building commercial plants to produce synthetic liquid fuels from natural gas, the Bureau of Mines is asking for more money and time to carry on its research program in that field.

The Bureau is presently operating under the Synthetic Liquid Fuels Act, passed April 4, 1944. That act specifies that no more than $30,000,000 is to be authorized for research and development work on methods of producing synthetic liquid fuels, and that the program is to run for not more than five years.

A bill introduced in the Senate Jan. 10 of this year by Senator O'Mahoney (D., Wyo.) would amend the earlier act by increasing the limit of expenditures to $60,000,000 and extending the life of the program to a total of eight years. Mr. O'Mahoney also introduced the original bill.

If the extra money is made available as proposed, the Bureau intends putting increased emphasis on research into the Fischer-Tropsch process. According to Dr. W. C. Schroeder, chief of the Bureau's Office of Synthetic Liquid Fuels, the cost of producing fuels by that method "appears to have dropped so materially" that the Bureau feels justified in pressing its studies more aggressively in that direction.

The Bureau states, in its annual report to Congress on the status of its synthetic liquid fuels program, presented by the Secretary of the Interior, that "it is estimated that gasoline can be produced from natural gas for 5½ to 7 cents a gallon." These figures are apparently based on using the Fischer-Tropsch process or a version of it.

The report also brings out that the Bureau so far has emphasized research on the coal hydrogenation process, and only now is turning its chief attention to the Fischer-Tropsch process. This same fact is evident in the Bureau's budget figures, shown in Table 1.

Technologists with the oil companies told PETROLEUM PROCESSING that economic studies some time ago showed that gas synthesis, rather than coal hydrogenation, would come closest to being competitive with petroleum refining, when and if it became necessary to make substitute fuels to supplement those from petroleum. The oil companies also feel that the technique of hydrogenation has been well worked out by the Germans, and would be applicable without further study if economic conditions warranted.

On the other hand, the oil companies in this country have found the means to make high-octane gasoline by Fischer-Tropsch methods, something which the Germans had *not* worked out. It is the Fischer-Tropsch process which is the basic method being employed in the commercial plants now under construction. A number of private companies

TABLE 1—Expenditures for Work on Synthetic Liquid Fuels*

Project	Estimate 1948	Estimate 1947	Actual 1946	Actual 1945	Accumulated Total
Hydrogenation and Gas Synthesis, Research and Development	$1,500,000	$1,856,140	$2,469,765	$1,571,969	$7,397,874
Hydrogenation Demonstration Plant	3,000,000	4,200,385	1,606,595	.....	8,806,980
Synthesis:					
Research on Gas Production	275,000	250,000	140,000	36,810	701,810
Demonstration Plant	500,000	1,042,000	.....	.....	1,542,000
Oil Shale:					
Research and Development	375,000	393,514	255,000	585,000	1,608,514
Mining	350,000	335,000	325,000	32,355	1,042,355
Demonstration Plant	1,000,000	1,000,000	780,000	370,467	3,150,467
TOTAL Obligations	7,000,000	9,077,039	5,576,360	2,596,601	24,250,000
Anticipated Obligations**	.....	410,000	.....	.....	.....
1945 Balance Available in 1946			−2,403,399	+2,403,399	
1946 Balance Available in 1947		−3,827,039	+3,827,039		
TOTAL estimate or Appropriation	5,000,000	5,250,000	7,000,000	5,000,000	22,250,000

* As contained in the Federal Budgets for the fiscal years 1947 and 1948.

** This amount represents a sum transferred in 1945 to the Dept. of Agriculture (but not yet obligated) for work on the production of synthetic liquid fuels from agricultural and forestry products, as provided in the Synthetic Liquid Fuels Act.

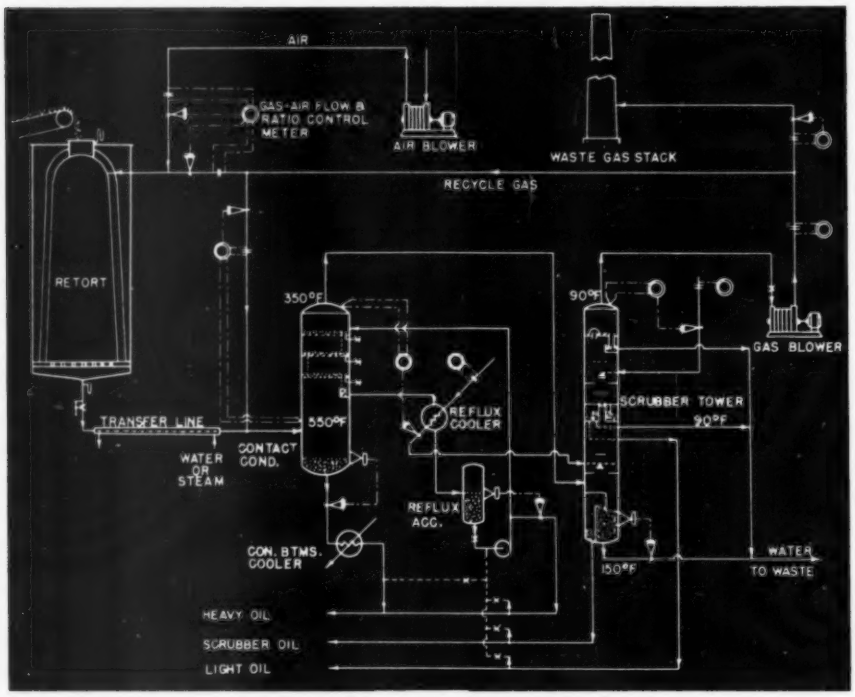

Fig. 1—Flow diagram of one of the batch-type retorts and its auxiliaries being installed in the Bureau's Oil-Shale Demonstration Plant at Rifle, Colo. Two such retorts are being installed, each capable of holding 40 tons of raw oil shale. The demonstration plant was scheduled for completion last month, and is expected by Bureau officials to be in operation during the first quarter of this year, producing initially 50 b/d of shale oil

have for several years been known to be conducting extensive research on improving the original process, developed over 20 years ago in Germany. These have included the M. W. Kellogg Co., Hydrocarbon Research, Inc., and several oil companies.

Over two years ago, Kellogg announced that its process had reached the stage where it was possible to make synthetic gasoline with a clear octane rating of 75 (motor method) at a cost of about 5 cents a gal., using natural gas.

A cost of 5¼ cents a gallon is predicted for 80-octane gasoline (clear, motor method) to be produced in one of the commercial plants now being built. This plant, located at Brownsville, Texas, will use the "Hydrocol" process developed by Hydrocarbon Research, and will have a capacity of over 7000 b/d of motor fuel and diesel oil. Natural gas will be its basic raw material. Seven private firms are financing the Brownsville plant at a cost of about $15,000,000.

Ground was broken last September on a 200-acre site, and operation is expected by the spring of 1948.

The other commercial plant will be built by the Stanolind Oil & Gas Co. (a subsidiary of Standard Oil Co. of Ind.) in the Hugoton field of Southwestern Kansas. It also will have a capacity of about 7000 b/d of fuels.

Further evidence of the advanced stage of private research and development work in the synthetic liquid fuels field was given last summer when the U. S. Navy ran a series of demonstration tests at Annapolis, using synthetic gasolines, diesel fuels and lubricants produced by several oil companies. These products of the oil companies' long-range research programs gave satisfactory performance in both gasoline and diesel engines.

It should be pointed out that the oil companies think of the development of synthetic fuels in terms of having the means available to make substitute fuels supplementary to regular petroleum supplies if, when, and as needed. They are not engaged in synthetic fuel research because they believe a shortage of petroleum supplies is imminent, but more as insurance against possible remote future needs.

Bureau's Progress to Date

The report of the Secretary of the Interior on the Synthetic Liquid Fuels Act details the progress made during the past year (Jan. 1 to Dec. 31) by the Bureau, summarizing the major progress and developments of the year and giving a detailed account of the engineering and scientific achievements.

All engineering and research work, as outlined in the report, is done at six field stations, as follows:

(1) Research and Development Division at Pittsburgh and Bruceton, Pa., investigating, on a scale up to about one bbl. a day, processes for converting coal to oil.

(2) Hydrogenation Demonstration Plant Division at Louisiana, Mo, designing and erecting a hydrogenation plant to produce about 200 b/d of oil or gasoline.

(3) Synthesis Gas Production Division at Morgantown, W. Va., developing efficient methods for making carbon monoxide and hydrogen from coal for use as raw material in some of the synthetic liquid fuel processes.

(4) Oil-Shale Research and Development Laboratories at Laramie, Wyo., developing fundamental chemical, engineering, and thermodynamic data and investigating on a scale up to one bbl. a day processes for retorting oil shale and refining the product.

(5) Oil-Shale Demonstration Plant at Rifle, Colo., erecting and operating a plant to retort 50 to 500 tons of shale a day and refining the product.

(6) Oil-Shale Mining Division, also at Rifle, Colo., operating mines to produce shale for the retorting plant and to determine costs of mining.

Hydrogenation Research

On the hydrogenation process the Bureau is following two paths in an effort to lower production costs, which they say appear to be two to four times the cost of producing gasoline from petroleum in the U. S. The first of these involves improvements in the present high pressure process to achieve much greater throughput, and the second development of a new process involving moderate pressures and minimum hydrogen consumption.

With regard to the first study, the Bureau reports that it "has under way investigations of processes which can reduce investment and operating costs on all of the major phases of the hydrogenation process."

In the second study, "laboratory and small pilot plant studies have shown that coal may be converted to a distillable oil at relatively low pressures (500 to 1000 psi) by employing special solvents or vehicles, relatively low temperatures, long contact times, and very active catalysts. Further experiments on this low pressure are in progress. Its success will depend in large measure on the development of highly selective hydrogenation catalysts."

Later in the report it is stated that "if such an improved process is coupled with low-cost strip mine coal from thick beds such as sub-bituminous or low-rank bituminous, which hydrogenates easily, the operating costs can be greatly reduced. A combination of such factors could place the process in a commercially useful range in comparison with oil and gasoline from petroleum."

Fischer-Tropsch Studies

One of the major engineering problems in the commercial application of the Fischer-Tropsch process is the large amount of heat which must be removed in the synthesis chambers to maintain the desired temperature. If this heat from the exothermic reaction is not removed rapidly enough, catalyst temperatures

rise and the products become gases rather than oil or gasoline.

The Research and Development Division reports that it "now has in operation a new type of chamber which controls catalyst temperature by dripping a cooling oil directly over the catalyst." In addition to doubling production rates over those achieved in European practice, it is said this cooling method permits a single chamber to be enlarged to any size practical from a construction standpoint.

Several other pilot plants are investigating still different cooling techniques which will be adaptable to large scale units for high production at low initial and operating costs.

A catalyst laboratory is searching for the best catalyst for the process, and also for those catalyst properties that control quantity and quality of yield. Thus far, this work has shown that a range of fuels can be produced by gas synthesis all the way from paraffins (suitable for Diesel engines) to isocompounds and aromatics (suitable for aircraft engines).

Hydrogenation Demonstration Plant

Expected to be in operation early in 1948 is a plant to produce daily 200 bbls. of gasoline or oil by coal hydrogenation. It will be located on the site of the government-owned synthetic ammonia plant at Louisiana, Mo.

The ammonia plant will be the source of all necessary utilities as well as the hydrogen needed, which will be purified and compressed to the maximum working pressure of 700 atmospheres (about 10,000 psi). Coal preparation equipment is to include crushers, screens, washer, and dryers.

About 80% of the coal will be converted to oil, it is stated, and will then be separated into high and low boiling material. The vapor phase operations will be carried out at 300 atmospheres in two stages or 700 atmospheres in one stage. At the higher pressure the middle oil is converted in a single stage to a highly aromatic gasoline with good octane and good rich mixture characteristics.

It is expected that the special attention paid to automatic controls will almost double the throughput ordinarily achieved with manual control.

Production of Synthesis Gas

An experimental model for studying underground coal gasification techniques is being built at a laboratory at Morgantown, West Virginia. "The over-all cost picture is very favorable to underground gasification methods," the report said. It was pointed out that it reduces or eliminates costs of mining, transportation, fuel preparation, and gas generator erection and operation.

Under a cooperative agreement between the Bureau of Mines and the Alabama Power Co., a tract of some four acres of coal land, containing a seam 30 inches thick about 30 feet deep, is being prepared for gasification studies. Work is expected to start early this year.

Small scale work is now under way, also at the Morgantown laboratory, on producing synthesis gas from pulverized fuel. Tests will be made mainly on the lower-cost coals—bituminous of low rank, and lignite.

Oil Shale Research

"The objective of the oil-shale research program is the development of processes and engineering information necessary for the design, construction and operation of large pilot plants or demonstration plants for producing oil from oil shale and for refining the oil into marketable products," according to the Bureau's report.

Much information has been obtained during the past year at the Laramie, Wyo., laboratory covering the chemical and physical properties of the shale as well as certain engineering data. For example:

Specific heats and the corresponding heat contents of selected samples of Colorado oil shale have been determined and are now in the process of publication.

Oil extraction from the shale by the use of hot solvents (thermal solution process) has developed from laboratory autoclave stage to a small semicontinuous pilot plant installation.

Studies on some of the German experimental retorting processes using molten aluminum-silicon alloy bath have shown the method impractical for commercial use. Though producing high yields in very short heating times, the method is costly because of losses of even small quantities of the high-cost metal alloy.

A means for estimating oil yields has been discovered. It was shown that the specific gravities and heats of combustion of Colorado oil shales are proportional to their yields, and their specific gravities are inversely related to the yield.

A new system for analyzing crude shale oils has been established which differs considerably from the Bureau of Mines Hempel method for crude petroleum analysis.

A method for the determination of hydrocarbon types in shale oil naphthas was developed and is now in use to determine the properties of various naphthas from both straight shale oil distillation and from other processing methods.

Demonstration Plant and Mining Studies

A demonstration plant and mining facilities for producing oil shale are set up at Rifle, Colorado. The plant and all necessary service facilities are expected to be in operation early this year.

Shale beds vary greatly in oil content; the richer ones, which in the Rifle area contain about 50 gals. of oil per ton of shale, are found in beds about four or five feet thick. Shales of medium oil content, around 30 gals./ton, occur in beds 50 to 70 feet thick; and lean shales, about 15 gals./ton, are found in thicknesses up to 500 feet.

The Rifle country is mountainous and thinly populated. It was therefore necessary to provide temporary housing for the employes as well as all service facilities—roads, water, sewage, and electricity. Fifty "pre-fab" housing units were erected. About 7.5 miles of gravel roads were completed in August, 1946, and a complete water system was completed about the same time. Electrical facilities will be finished about March of this year.

The oil shale crushing, screening, conveying, and retorting equipment was scheduled for completion in January, 1947, as were various auxiliary buildings—boiler house, warehouse, machine shop, laboratory, and instrument shop.

During the heavy construction program, some oil shale has been produced and shipped to other points where two special types of retorts were available.

Core drilling at the Rifle mine has indicated that the western Colorado beds are richer in oil than was previously considered. The site, known as Naval Oil Shale Reserve No. 1, contains a reserve in the main zone of approximately 15 billion barrels of oil, equivalent to about 75% of the known petroleum reserves in the entire United States.

However, the amount which the Bureau of Mines feels can be mined and retorted at a reasonable cost is about 3.5 billion barrels of recoverable oil. It is added that this "of course, is only a small fraction of the total oil shale in the U. S."

Underground workings have been completed for supplying the Rifle demonstration plant with selectively mined shale of any richness from 10 to 60 gals./ton oil content.

A second mine has been opened for operating on the basis of 5,000 tons/day for direct determinations of mining costs. Although under ground, this mine will be operated like a quarry. Entry ways are 26 by 18 ft., so that an electric or a Diesel shovel can be taken underground. It is believed that costs in the neighborhood of 50c/ton of shale mined can be achieved by the quarrying method using large capacity materials-handling equipment.

Considerable progress has been made on drilling methods. A drill bit has been developed that will cut through 100 to 200 ft. of shale without material loss of drilling speed. Bits previously available were dull aftter 10 or 20 ft. of drilling. A jumbo drill is under development that will drill 4 to 8 holes at once, it is said.

TOMORROW

... IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Synthetic rubber faces uncertain future.**
- **Experiment with underground gasification of coal.**
- **Vinyl plastics face rapidly expanding market.**
- **Colloidal fuel study predicts competition for fuel oil.**
- **Synthine diesel fuels attract continued study.**

Synthetic Rubber Faces Uncertain Future

ALTHOUGH the entire synthetic rubber versus natural rubber situation is much confused, several pertinent facts are beginning to emerge:

(1) World supply of natural rubber in 1947 may approximate 1,200,000 long tons, compared with a total 1946 supply of 850,000 tons. As much as 800,000 tons of this 1947 supply are expected to be available in this country(1).

(2) Total U. S. consumption of both natural and synthetic rubbers in 1947 (presumably including stockpiling) will approximate 1,000,000 tons.

It takes no involved calculus to figure out that, if all controls were relaxed and manufacturers were permitted to use all the natural rubber they could obtain, only 200,000 tons of synthetic rubber would be required this year to balance supply and demand. Even less would be required in 1948—and this from an industry with an annual capacity of close to a million tons.

Further complicating the picture is the general public opinion that synthetic rubber is inferior.

The controls, however, are not likely to be relaxed, particularly the rubber order requiring the use of specified amounts of synthetic rubber in various products, ranging from a small percentage in heavy-duty truck tires to nearly 80% in some passenger tires and even more in farm tires. Congress, despite its anti-control attitude, is expected to produce some form of continuation of that order, which otherwise would die March 31 with the Second War Powers Act.

Two arguments favor the continuation of such control. First, the government recognizes the need of keeping the young synthetic rubber industry alive for obvious military reasons. Second, tire producers welcome the guaranteed supply of synthetic rubber as protection against the wild gyrations in the world price of natural rubber.

Both of these are valid reasons. The public will be the chief sufferer if its unreasoning preference for "all rubber" products runs synthetic rubber off the market, and the nation may suffer defeat in a future war if synthetic rubber plants all close their doors. Those plants which are most economic—perhaps with a combined yearly capacity of 250,000 tons—should be operated, preferably under private ownership. An additional capacity of 350,000 tons per year should be kept in standby condition.

It goes almost without saying that the economic plants will be chiefly petroleum industry butadiene plants, so the petroleum industry has a concrete interest in the situation to add to its altruistic desire to see the nation protected.

Experiment with Underground Gasification of Coal

ENGINEERS have long believed that the most efficient thermal use of coal lies in its complete gasification and subsequent use. By this method, valuable by-products may be recovered, ash may be separated, and a more easily handled (gaseous) fuel may be obtained.

Much of this may be made possible by improvements on recent German-developed processes of continuous gasification with steam and/or oxygen or air, but all these processes require that the coal be mined before processing. With these facts in mind, with a knowledge of Russian experiments, and "with its eye on possible coal mining economies and on utilization of coal veins difficult or impossible to mine, the Alabama Power Co. is preparing to test the feasibility of generating producer gas for power purposes by burning unmined coal right in the ground.

"To carry out this experiment in underground gasification of coal, the power company, with the U. S. Bureau of Mines cooperating will isolate a coal vein in a new mine at Gorgas, Ala., set it afire, feed it air and perhaps oxygen, draw the resulting gases out of the mine, cool and detar them, then store them for use in its power plant nearby(2)."

Numerous accounts of Russian experiments in this field have appeared in recent years, since underground gasification of coal is also of interest as a means of producing a synthesis gas for the Synthine (Fischer-Tropsch) process and related syntheses (ammonia, methanol, etc.). According to a recent review, there are four different methods which have received Russian attention, these methods differing considerably as to the amount of underground preparation required and in their applicability to types of coal seams. The method which will be used in Alabama differs somewhat from most of these, possibly because it is adapted to the particular deposit.

"The experiment will be carried out on a coal seam located in a 400-ft. neck of land jutting out from a larger hill. A trench 20 ft. wide will be bulldozed across the base of this neck of land, isolating the coal seam, which is 30-40 in. thick and 40 ft. wide. Horizontal shafts 6 ft. in diameter will be driven into the hill from the trench, and connected at the downslope end.

"The plan is to fire the face of the coal vein at the deep end. Air will be blown in one shaft and the producer gas drawn out the other as the coal burns toward the cutoff trench. To allow engineers to follow the actual gasification processes, peep holes will be drilled into the air and gas shafts."

Oxygen would be used instead of air if the higher cost were economically offset by the higher Btu value of the product gas, which would contain much less nitrogen. If a Synthine synthesis gas were desired, steam would also be used to produce the desired mixture of carbon monoxide and hydrogen; here, however, "heat must be supplied to keep this reaction (coal plus steam yields hydrogen and carbon monoxide) going, and the problem is to prevent the temperature of the coal from dropping so low that carbon dioxide instead of carbon monoxide results."

Underground gasification might prove of particular interest for use with coals such as lignites, which are (at present, at least) of too low a grade to be worth mining in the usual way, and even, perhaps, in the recovery of shale oil from oil shale; a few experiments in this latter field have already been conducted, as mentioned last month in this feature.

The experiments in Alabama will be under way early this year and may last for over a year; they will cost $50,000-$70,000. From them, the Bureau of Mines "hopes to get the answers to several major questions, including the smoothness of gasification underground; efficiency of gas reclamation; amount of

(1) Anon., *Business Week*, No. 905, 7 (1947), "Rubber Control to Stay?"

(2) Anon., *Business Week*, No. 898, 17 (1946), "Unmined Coal Will Be Burned for Gas."

precipitation of tar in pipelines; advantages of air, oxygen, and perhaps steam feeding; and by-product percentages."

Information of this type will be of great importance, since "the Russian figures, while showing a per-man output (thermal equivalent) of 100-120 tons per month, compared with 30 tons per month by regular mining, are hardly conclusive when it is remembered that the United States average production of bituminous coal was 5.2 tons per man-day in 1941, far above the Russian average. Nevertheless, this method offers economic and sociological attractions and is definitely worthy of additional attention."

Vinyl Plastics Face Rapidly Expanding Market

MANY plastics were produced in increasing quantities during the recent war, but few underwent so great an expansion as occurred in the field of the vinyl resins. These plastics are of particular interest to the petroleum industry in that their basic raw material is either acetylene or ethylene, depending on the process; both of these substances are or may be derived from petroleum.

Production of vinyl resins totaled 12,000,000 pounds in 1940, representing a rapid growth over preceding years, but this figure is dwarfed by the annual production rate of 119,600,000 pounds which existed in April of this year. However, J. J. Newman, vice-president of the B. F. Goodrich Co., has recently stated[3] that "his company's business research department has surveyed potential markets for Koroseal (a vinyl plastic), and, in the section of its report dealing with products from coated fabrics, coated paper, film, and sheeting, the indicated potential market, in terms of resin content, was 400,000,000 pounds, whereas the actual use of vinyl resins in such types of merchandise was at the annual rate of 35,000,000 pounds."

As evidence of his company's faith in the future of plastics, Newman "cited its new $5,000,000 plastics processing plant at Marietta, Ohio, and the fact that Goodrich has purchased the synthetic rubber plant it built and operated for the government at Louisville, Ky., and will have an investment of approximately $7,500,000 in it, mainly for the production of polyvinyl chloride[3]."

Another leading producer of vinyl resins, the Carbide and Carbon Chemicals Corp., has recently revealed that its $15,000,000, two-to three-year expansion program at Texas City, Texas, will include units for the manufacture of Vinylite resins. "Only the basic resins will be produced; no fabrication will be done at the Texas City plant[4]."

According to another source[5], "producers (of vinyl plastics) report capacity production of the vinyl plastics. Demand for vinylidene chloride (Saran), polyvinyl chloride, and copolymer resins and compounds, especially the elastomeric type, is approximately three times the available supply. During the latter part of 1945, full capacity of the industry was not utilized because of reconversion problems. With the change from war to civilian production, the end use pattern changed extensively. Based on Census' reports for seven months, the increase this year over the last five months of 1945 is roughly estimated at 50%. Other vinyl plastics such as polyvinyl butyral and polyvinyl acetate, although running at higher production rates, are believed to be in sufficient supply."

In August of last year, total plastics production was running about 48% above the 1945 rate, and it was stated[5] that the completion of new, planned facilities would bring capacities to 3½ times the 1945 volume. Putting this another way, J. J. Newman[3] has pointed out that "the national dollar-volume consumption of all types of plastics had grown from $20,000,000 to $95,000,000 in the years 1936 through 1940 and, further stimulated by the war needs, would reach $750,000,000 this year—37½ times what it was only ten years ago."

Such growth figures are ample cause for the current popular enthusiasm in regard to plastics. These substances are not miracle materials, nor are they the duds which some rash users, whose fingers were burned through nonscientific use, would like to believe. Instead, they are a group of materials whose properties are sufficiently different from other substances, or whose costs are sufficiently low as to render them useful in many fields.

Colloidal Fuel Study Predicts Competition for Fuel Oil

DURING the recent war, a great deal of attention was given to the development and use of colloidal fuels, made of finely pulverized particles of coal suspended in a suitable vehicle, usually oil.

While interest in this subject has waned considerably since the end of hostilities, a recent report[6] of some work on it is rendered of some significance by two of the conclusions it draws:

"The combustion of colloidal fuel containing 40% of coal by weight was equal to, or better than, that obtained with either powdered coal or fuel alone.

"The economic advantages of colloidal fuel will become increasingly attractive as fuel oil supplies become more limited."

The Kansas State experiments were concerned with: (1) grinding of the coal, (2) mixing of the coal in oil, (3) flow of the oil-coal mixtures in pipes, (4) stability of colloidal fuels in storage, (5) combustion of colloidal fuels, and (6) economics of manuafacture and use.

Some of the advantages claimed in the bulletin for colloidal fuel are that it can be pumped like oil, may be cheaper than oil in many localities, and has a heating value, on a volume basis, which is higher than either oil or coal alone. The report also claims that colloidal fuel can be burned in present oil burning equipment with efficiency.

Synthine Diesel Fuels Attract Continued Study

AS MENTIONED in PETROLEUM PROCESSING last month[7], the Synthine (Fischer Tropsch) Diesel fuels employed by the Navy in its demonstrations at Annapolis last year were definitely acceptable or superior by almost every present standard. The cetane number of the Diesel fuel supplied by The Texas Co. was only of 42.9 cetane number, but that furnished by Standard Oil Co. (N. J.) had a cetane number of 70, and it was clearly stated that this property varied with the process conditions and desired yields, so that the low cetane number of The Texas Co.'s samples is probably not typical.

Indeed, as mentioned in an early installment[8] of this series, Diesel fuels from the normal, German-type Synthine process are often of 90-100 cetane number, although gasolines are concurrently paraffinic and of low octane number. It is quite natural, of course, that paraffinicity of the American Diesel fuel fractions should be sacrificed in domestic operations to the more-economically-important octane number of co-product gasolines, but it should again be noted that the cetane number of the Jersey Standard samples was 70—a reasonable high number.

The Diesel fuel to be produced at the proposed Brownsville, Texas, plant of Carthage Hydrocol, Inc., is expected to have a gravity of about 38° API, a cetane number of 45-50, and a pour point below 0° F. This product of a Synthine process using an iron, fluidized catalyst may be typical of Synthine Diesel fuels which will be produced as the industry develops, or fuels of higher quality may be produced by deliberately varying process conditions, but in any case one fact is clear—if the Synthine process is eventually used on a large scale, Diesel fuels will be available in a quality range equal or superior to present Diesel fuel levels—a comforting thought for the Diesel engine industry.

(3) Anon., *Rubber Age* 59, No. 7, 86 (1946), "Tenfold Increase in Vinyls Seen by Goodrich Officials."

(4) Anon., *Chemical and Engineering News* 24, No. 22, 3066 (1946), "Carbide and Carbon to Make Vinylite in Texas."

(5) Carman, F. H., *Chemical Engineering* 53, No. 11, 158 (1946), "Plastic Materials: Review of Supply Outlook."

(6) Jonnard, A., *Colloidal Fuel Development for Industrial Use*, Kansas State College, Engineering Experiment Station Bulletin, No. 48, 1946, 93 pp.

(7) Anon., PETROLEUM PROCESSING 2, No. 1, 37 (1947), "Oil Company Synthetic Fuels and Lubes Show Good Records in Navy Tests."

(8) Anon., NATIONAL PETROLEUM NEWS, *Technical Section*, 36, No. 36, R-585 (1944), "Keeping Up With the News—Diesel Fuels from the Synthine Process."

Better Fuel Economy for Tomorrow's Cars Through Surer Control of Knocking

Scientific Intruments Now Can Replace the Human Ear As the Medium for Detecting and Measuring Detonation, Making Possible Closer Adaptation of Fuels and Engines

A STAFF REPORT
by the Editors of
Petroleum Processing

Greatly improved engine and fuel testing methods and instruments will play an important part in bringing about fuel economy as well as better performance of the cars of the future.

Through the installation of scientific engine knock indicators developed during the war, impressive savings are already being made in commercial aircraft operations, it was reported at the annual meeting of the Society of Automotive Engineers in Detroit, Jan. 6-10.

The same type of detonation testing apparatus is already commercially available for laboratory and road test work on automobile engines, it was also announced. The use of this or other scientific apparatus for the same purpose will make possible studies of fuel volatility and distribution which could not be made when the human ear had to be relied upon as the medium for detecting and measuring the knocking of an engine.

"Automotive engines and fuels have progressed to the point where further developments in their mutual adaptation necessitate satisfactory detonation and engine analysis instrumentation," one engineer told the SAE meeting.

Another important development reported to the SAE was a new type of Diesel engine oil which, it is believed, can offset or inhibit engine wear from the corrosive effects of sulfur in Diesel fuels. Below are reviews of SAE papers describing the above and other important developments of the SAE meeting.

Detonation Indicators Achieve Fuel Economies For Aircraft; Reduce Waste, Overhauls

SAVINGS to aircraft operators of millions of dollars annually are possible through the use of positive means for detecting detonation in full-scale aircraft engines such as are now available, J. S. Bogen, Universal Oil Products Co., told the SAE meeting. The savings would result from less wastage of fuel, longer intervals between overhaul, decreased overhaul time and necessity for fewer replacement parts.

This paper, entitled, "Aircraft Detonation Indicators," prepared in cooperation with W. J. Faust, also of UOP, summarized the development and application of detonation indicators for both full-scale and laboratory aircraft-engine testing. Among oil companies, Phillips Petroleum Co. and Standard Oil Co. of California were named as playing an important part in developing detonation instrumentation.

"Published flight test data have shown," it was stated, "that under some level cruise conditions, the determination of the safe minimum specific fuel consumption with detonation indicators may save as much as 34% of the fuel used under typical airline procedure, the average saving aproaching 20%. Transport executives estimate the value of a pound saved at anywhere from $200 to $600 during the life of a transport plane.

"Conservatively calculating that the value of a pound is $200 in the life of a transport plane and that, during a single flight, a 120-lb. detonation indicator on a four-engine plane would save 1800 lbs. of the previously required 18,000 lbs. of fuel, the net weight saving of 1680 lbs. would represent a total gain for the life of the plane of $336,000, assuming a 100% load factor."

Even at levels of detonation intensity lower than those normally considered damaging, erosion of engine parts will occur upon prolonged operation (over 700 hours) it was brought out. At higher levels of detonation, serious erosion or complete failure of pistons, valves, valve seats or other parts may take place after short periods of operation. A detonation indicator will not only prevent failures of the above nature but will often indicate other mechanical failures or improper operating conditions such as incorrect valve adjustment, broken spark-plug insulators, broken piston rings and cracked cylinder barrels.

"Instrumented flight tests enabled one airline to reduce its rate of piston failure from 6.8 per 10,000 hours to 1.5 by changing carburetor take-off settings, and to further reduce its rate of piston failure from 1.5 to 0 per 10,000 hours by a change in cruise conditions," it was stated.

Great progress was made during the war in the development and application of detonation indicators for air-craft engine testing, under the sponsorship of the Army Air Forces and the Navy Bureau of Aeronautics. At present there are available several methods of obtaining the detonation signal, amplifying it and indicating its intensity or presence. Although some of the instruments were developed for a single purpose, they could all be adapted to experimental testing in either the laboratory or in flight. They were reviewed as follows:

"The spark-plug, strain-gage pickup is the easiest to install, requiring no mounting facilities; its life, however, is limited by that of the spark plug itself.

"The electromagnetic diaphragm type is inserted directly into the combustion chamber wall; its sensitivity may be varied by changing the diaphragm, and it has the advantage of indicating combustion pressure functions when used with the oscilloscope for experimental testing; the diaphragm is subject to fatigue and must be replaced periodically.

"The magnetostriction diaphragm type is also inserted directly into the combustion chamber wall and will indicate com-

bustion pressure when so desired. The magnetostriction vibration type of pickup is relatively simple to install on most engines, has no moving parts, and has good sensitivity to the high-frequency engine vibrations caused by detonation.

"Unwanted pickup signals are eliminated in some instruments by a mechanical commutator; in others the same result is obtained by use of electronic switches, triggered amplifiers, threshold amplifiers, or by manually decreasing the sensitivity so that only the stronger signals are indicated.

"Methods of indication include the oscilloscope for experimental laboratory and flight testing, and steady-reading meters or instantaneous peak-reading meters for laboratory and fight testing. For routine flight operation, detonation is indicated by a flashing light.

"Complexity of controls has been eliminated. Excepting only the use of the oscilloscope, none of the indicating circuits require more than one adjustment. One of the routine flight instruments requires no adjustment during operation."

The organizations participating in the development of detonation instrumentation for full-scale aircraft engines are: Allison Division, General Motors Corp.; Brown Instrument Co.; NACA Aircraft Engine Research Laboratory; Phillips Petroleum Co.; Sperry Gyroscope Co.; Standard Oil Co. of California; Weston Electrical Instrument Corp. Those participating in the development of laboratory instrumentation are: Brown Instrument Co.; Coordinating Research Council; Electro Products Laboratories, Inc.; National Advisory Committee for Aeronautics; Phillips Petroleum Co.; Sperry Gyroscope Co.; Standard Oil Co. of California.

Automobile Knock Indicator

A commercial detonation indicator for automobile engines, as developed by the Sperry Gyroscope Co. from known aviation knock instrumentation methods, was described at the SAE meeting by J. H. Goffe and J. W. Wheeler, of that company's engineering division. Basically it consists of a pickup of vibration from the engine, a selection by electronic means of those frequencies caused by detonation and measuring the knock intensity by an electrical meter.

It is claimed the equipment will (1) detect and measure knock level rating fuel similar to the ear of a skilled operator; (2) detect which cylinders are knocking (3) record the knock level against traces from which speed may be measured; (4) assist in analysis of abnormal engine vibration conditions due to valves or other sources.

"Approach" to Selection of Compression Ratio to Fit Fuel Anti-Knock Quality

BETTER correlation of engine compression ratio and spark advance curve with the characteristics of the motor fuels available was proposed by Errol J. Gay and Henry T. Mueller, of Ethyl Corp., as a means for securing improved engine performance and fuel economy. They presented a technique or "approach" for working out such a correlation and gave data from one application in the design of an automobile engine which has been in production over a year and is widely distributed over the U. S.

Their method is based on a modification of the so-called Borderline method for rating anti-knock motor fuels on the road which was adopted by the Co-operative Fuel Research Committee of the Coordinating Research Council in 1941. It takes into consideration the fact that engine speed and spark timing influence the effective anti-knock quality of a motor gasoline. Also that fuels of the same ASTM Motor method octane rating may respond differently in multi-cylinder engines, depending upon the fuel's inherent "sensitivity" to differences in engine operating conditions, especially speed and spark advance. ("Sensitivity" is defined as the difference between the higher Research method octane rating and the Motor method rating.)

"The motor gasolines which the oil industry is currently producing are more sensitive than their pre-war fellows," it was brought out in this paper. "This increase in sensitivity is due, in large part, to the advent of catalytic cracking. It is to be expected that more sensitive fuels will be the rule rather than the exception over the next decade. Such fuels introduce certain problems into the older concepts of the fuel-engine relationship. But if engines are designed in full knowledge of the significance of fuel sensitivity, they may also permit the manufacturer to achieve greater performance for any given Motor method octane level."

The modification of the Borderline test method developed by Ethyl Corp. was used during the war to determine the octane number and suitable ignition advance requirements of military engines. Later, cooperative programs were undertaken with a number of manufacturers of commercial equipment to study the possible effects of gasoline antiknock quality on the choice of compression ratio and spark timing.

In the work, a dynamometer setup is used which approximates the engine installation in a vehicle. A standard induction system is used which includes standard carburetor calibration, complete air cleaner assembly and normal intake manifold heating, taking into consideration the end use of the engine such as a bus or truck installation. A standard exhaust system including muffler is used, also a standard engine cooling fan. Engine operating temperatures are kept on the high side of warm weather conditions.

Test fuels used cover a range of octane ratings. The test gasolines are selected in pairs, each pair being closely matched on a Motor method octane number basis, but with one fuel representative of a low sensitivity type and the other a high sensitivity type. Gasolines which have a Research rating less than 3 octane numbers above their Motor method rating are considered low sensitivity fuels, while those that have an 8 to 10 octane spread are considered high sensitivity fuels. Such gasolines provide the possibility of studying not only the effect of Motor octane number alone, but also the effect of fuel sensitivity on the knock-limited performance of the engine.

Borderline curves are made for the various test fuels, which show the fuel's ability to tolerate spark advance throughout the engine speed range and thus represent the dividing line between non-knocking and knocking operation. From this data and that secured from reference fuels, a compression ratio and compromise spark advance curve can be selected which will provide best performance and economy for fuels of the type most widely available commercially, it is said.

Tests following this approach have been completed on several engines, it was brought out in the paper. From such data, a compression ratio of 7.3 to 1 and a best-compromise spark advance curve were selected for a representative engine of recent design, for the utilization of gasoline in the anti-knock quality range of 72 Motor-77 Research to 81 Motor-86 Research octane number.

"This engine has been in production over a year and is in wide distribution throughout the U. S.," it was stated. "It has been operated on a wide variety of gasolines which have differed markedly in Motor method octane number and sensitivity. The reduction in anti-knock quality of gasolines brought about by the recent metallic lead shortage has made it necessary in many areas to use gasolines of 72 Motor and 74 to 78 Research octane number." The broad experience of satisfactory operation in service apparently has justified the selection of the 7.3 compression ratio and the particular distributor curve, it was stated.

"A last final point of interest," it is concluded, "is that the engine does not necessarily judge anti-knock value in accordance with either Motor or Research octane number alone. A fuel of 75 Motor-85 Research may be better than another fuel of 78 Motor-82 Research or vice-versa, depending on the engine in which the fuel is used. Taking advantage of the amount of permissible spark ad-

vance up to the point of trace knock or best power, over the operating speed range of the engine as related to fuel quality, is the key to the story.

Official title of this paper was "An Approach to the Selection of Compression Ratio as related to Fuel Anti-Knock Quality." Mr. Gay is manager of the Commercial Engine and Fleet Division, and Mr. Mueller manager of the Technical Development Section, Technical Service Department, Ethyl Corp.

Lower Volatility of Postwar Gasolines Lengthens Engine Warm-Up Period

PERFORMANCE characteristics of postwar motor fuels in the "warm-up period" of the engine were described in a paper given by J. G. Moxey, Jr., assistant chief engineer, Automotive Section, Development Division of Sun Oil Co. Data presented was the result of tests made by the company last winter.

With present day catalytically cracked fuels of decreased volatility, the average 65% point in the distillation range was given as a measure of warm-up ability. Ten to 15 years ago the characteristic of the gasoline which influenced warm-up was a volatility point somewhere around the 50% point. Warm-up is defined as the period between the time a cold engine is started and the time that completely flexible operation is obtained.

"On account of the increased amounts of high boiling, high-octane gasoline fractions available from refining equipment installed during the war, there may be expected a lowered volatility of gasoline," states the conclusion of this paper. "It would be well for the automobile manufacturer to recognize this fact and give it due consideration in the design of future engines."

During the prewar years, it was brought out, the trend was toward a lighter, more volatile gasoline. Fig. 1 plots the 50 and 90% points of average winter gasoline for the period 1929-1946, except for the wartime period. This was due to efforts of refiners to increase the anti-knock quality of their motor fuels by cutting out the high boiling, low-octane fractions in their processing. This relationship is exemplified in Fig. 2, which shows typical unleaded octane ratings plotted against mid-boiling points for successive fractions of straight-run gasoline from crude and thermally cracked gasoline.

Cat Cracking Produces High Anti-Knock

The characteristic of catalytic cracking to produce high anti-knock quality material in the high boiling range, as well as in the lighter fractions, is illustrated in Fig. 3, which shows the distribution of anti-knock quality throughout the boiling range of typical catalytically cracked gasoline.

"The refiner with catalytic cracking equipment, therefore, (and nearly all the larger refiners have it)," states the paper, "no longer has the incentive of higher octane to prompt him to discard the higher boiling fractions of his gasoline, and he certainly is going to be more and more resistant to cutting down on his yield and increasing his cost by discarding this material.

"It is the author's opinion, therefore, that the next few years will see a reversal of the prewar trend toward lower boiling points and a reappearance of the problem of the proper utilization of heavier fuels. As a matter of fact, this reversal has already been indicated by survey data of the average motor gasoline marketed during the first postwar winter."

In the test work of Sun Oil Co., warm-up ability was expressed in terms of the elapsed time between a cold start and the first completely flexible snap-throttle acceleration when the car was operated on a level road at a constant speed of 20 mph. with snap-throttle accelerations from 15 mph. at one-minute intervals. This test procedure was thought to be extremely severe and one of the reasons for its choice was its ability to differentiate between comparatively small changes in atmospheric temperature, in fuels and in engine operating conditions.

Representative fuels were used in four cars in essentially new-car mechanical condition. "However, the average car on the road today is by no means a new car," it was stated, and it would be normal to expect that the generally poor mechanical condition of the average car as it is now being driven would have a detrimental effect on its warm-up ability. This was found to be the case.

Warm-up characteristics of 28 cars were studied for operation with a fuel of average volatility, at 30° F. atmospheric temperature. These cars were taken off the road and were chosen as a representative cross-section of the cars on the road today. They were all considered to be in satisfactory operating condition by their owners and were not altered prior to testing.

"A very wide difference between the warm-up ability of the various cars is apparent," comments the paper, in referring to these latter tests. "Several never did give completely flexible performance. This wide difference might be expected, however, when the poor mechanical condition of the cars on the road today is consid-

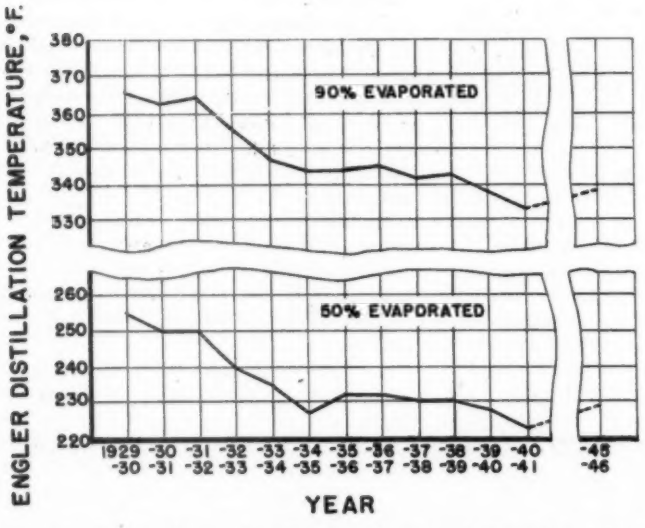

Fig. 1—Comparison of volatility characteristics of average winter gasolines, as shown by the 90 and 50% distillation points, for 1929-46, with the war years omitted

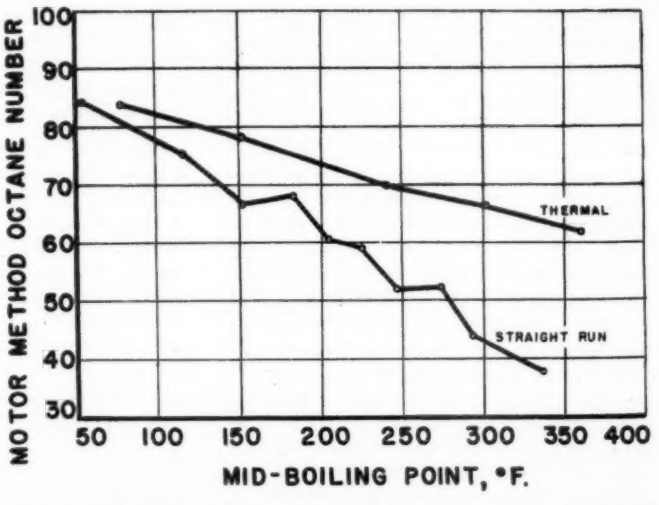

Fig. 2—Distribution of anti-knock quality throughout the boiling range of typical straight-run and thermally cracked gasolines. (Fractions from iron still distillation-3:1 reflux ratio)

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FOR NATURAL • SEE WARREN

NATURAL GASOLINE
Chemical Grade
HYDROCARBONS
Iso-Pentane
Normal Butane
Iso-Butane
Propane
Hexane
STA-VOL-ENE

BEFORE YOU CONTRACT • MAKE A WARREN CONTACT

The Natural you buy must be as good as Warren Stabilized or Sta-vol-ene to give your finished motor fuel: Constant Uniformity . . . Complete Combustion . . . Instant Vaporization . . . Power and Pep . . . High Volatility . . . Pick-Up and Speed . . . Quick Warm-Up . . . High Octane . . . Instant Starting.

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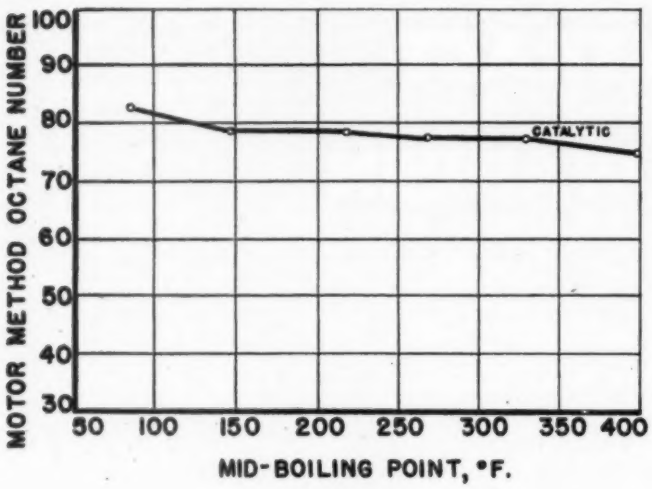


Fig. 3 — Distribution of anti-knock quality throughout boiling range of typical catalytically cracked gasoline. (Fractions from iron still distillation-3:1 reflux ratio)

ered in addition to the differences due to inherent engine design.

"Such mechanical faults as improperly operating or improperly set accelerator pumps, stuck manifold heat valves, dirty manifold hot spots, inoperative coolant thermostats and many others were found in these cars, all of which could be expected to adversely affect warm-up. It was found that warm-up ability could be improved by increasing the volatility of the fuel, but a point of diminishing returns was reached in each car beyond which very little improvement could be obtained by means of the fuel alone."

Official title of Mr. Moxey's paper was "Engine Warm-up with Present-Day Fuels and Engines."

Lube Oils May Be Tailored to Offset Effects of Sulfur in Diesel Fuels

TEST work done by Union Oil Co. of California on the influence of fuels in the wear rate of Diesel engines has shown that lubricating oils can be made which will largely offset the increased wear resulting from the use of a high sulfur fuel. This phase of the test work is referred to in a paper by C. C. Moore and W. L. Kent, of that oil company, entitled "Effect of the Nitrogen and Sulfur Content of Fuels on the Rate of Wear in Diesel Engines."

Fig. 4 from the paper shows the wide range of wear rate that can be obtained with different lubricating oils when operating under identical conditions as regards fuel, coolant temperature, and other factors. Oil A is the commercial heavy-duty lubricating oil used in the wear tests on Diesel fuels; Oil B is also a heavy-duty oil but with a different additive. Oil C was an oil specially compounded to combat the effect of sulfur in the fuel and it will be noted that the rate of wear is only 27% of that obtained with Oil A. The paper states it is believed there is considerable promise in the development of an oil such as C to combat corrosion in Diesel fuels.

In a later interview a representative of Union Oil Co. stated that this work is still in an experimental stage but that the development is covered by patents and the company eventually plans to put an oil of this nature on the market. The nature of the type of additive used has not been announced. The experimental studies indicate it is effective regardless of the nature of the particular sulfur compounds in the fuel, it was stated.

Some thought has been given to extending the studies to the gasoline engine field but it is felt that conditions may be more difficult there than in Diesel engines, with their higher operating temperatures, pressures and excess of air.

Cheaper to Rebuild

A Diesel engine manufacturer is quoted as recently stating he could better afford to rebuild his engines after 2000 hours of operation rather than to pay one cent a gallon premium for fuel. This was said to indicate the economic possibilities in developing a crankcase oil which would inhibit or offset engine wear from high sulfur fuels and thus extend engine life.

The general study of Diesel fuels by the Union Oil Co. was undertaken because of the experiencing of very severe cylinder wear in certain marine installations along the Pacific Coast shortly after the end of the war. Fuel was not always obtained from the same source and, although the lubricating oil was generally a constant, there were many cases where different engines with the same lubricating oil gave widely different rates of wear. In each case there were enough variations in operating conditions and mechanical arrangements of the exhaust system, cooling system and so on so that no single item or condition could be determined as the principal cause of wear.

A study of fuels used by the engines showing the greatest wear indicated that frequently high wear and high nitrogen content of the fuel occurred together. It was also noticed that, along with the high nitrogen content, there usually occurred a high sulfur content. One other impurity present in Pacific Coast Diesel fuels is naphthenic acid, the paper brought out, and it was known that at elevated temperatures naphthenic acids attack iron.

The test work was done on a single-cylinder, 5¾ bore, 8-inch stroke Caterpillar test engine. Analysis of the crankcase oil for iron content was the method used to measure wear of the engine. The amount of iron in the oil at one hour, as calculated, was taken as the blank or starting point in calculating wear. Calculations were made for 20, 40 and 60-hour sampling periods, thus giving a series of wear values which may be plotted against time of operation.

In the tests for evaluation of effect of nitrogen content in fuels on rate of wear, six fuels were selected. Two were commercial West Coast Diesel fuels (A and D in Table 1) and the other four were treated to secure test fuels with varying amounts of nitrogen, naphthenic acid and sulfur content. Results of the tests showed that nitrogen compounds in the fuel had little effect on wear rates, even where nitrogen bases had been added to give over twice the original nitrogen content of the fuel.

The tests did demonstrate, the paper states, that sulfur had a profound effect on rate of wear in a Diesel engine and also that the source of the sulfur content was not significant. A series of test runs was made with fuels prepared by adding different amounts of thiophene to the light commercial Diesel fuel of originally low sulfur content. Thiophene was chosen as the sulfur-containing agent since materials similar to thiophene occur naturally in Diesel fuels. Test results showed

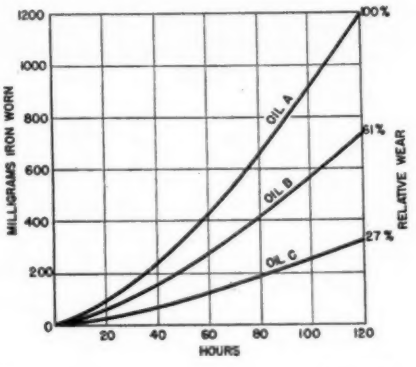


Fig. 4—Range of Diesel engine wear rate with different lubricating oils. A is commercial heavy-duty Diesel engine oil; B is same oil but with different additive; C is special oil compounded to combat effect of sulfur in the fuel

TABLE 1—Analyses of Diesel Fuels Used in Union Oil Co. Tests

Fuel	A	B	C	D	E	F
Gravity, °API @ 60° F.	32	32	32	41	41	41
Flash Point, PMCC, °F.	190	200	...	200	...	...
Pour Point, °F.	0	5	...	—35	...	...
Color, NPA	4¼	2½	...	1—	...	...
Viscosity, SUS, @ 100° F.	39	39	39	34	34	34
Engler, % Distilled, °F.						
Initial	415	416	416	400	400	400
10%	471	476	476	453	453	453
50%	541	544	544	463	463	463
90%	679	680	680	500	500	500
Maximum	716	724	724	560	560	560
Carbon Residue on 10% botts, wt. %	0.10	0.10	...	0.03	...	...
Acid No., ASTM	0.3	0.0	0.0	0.0	0.0	0.0
Sulfur, wt. %	0.7	0.7	0.7	0.0	0.0	0.7
Nitrogen, wt. %	0.08	0.01	0.17	0.00	0.17	0.00
Cetane No.	44	44	...	51	...	...

varying amounts of wear with increases in sulfur content. Study of the wear rates of two heavy Diesel fuels, in conjunction with data obtained from light Diesel fuels, indicated that boiling range as such had no effect on wear.

Navy's Work in Diesel Fuels

The primary interest of the Navy, Capt. W. C. Latrobe, Bureau of Ships, Navy Department, told the SAE, is to influence by all means at its disposal the development and manufacture of Diesel fuels and engines which will have the highest specific power output possible commensurate with the economy of the nation. The Navy realizes that advancements in the quality of Diesel fuels must keep abreast or even ahead of engine design. On this point he said; "Indeed, it is even believed in some quarters that some of our existing fuels may be too good for present engines."

Referring to the 90-cetane Fischer-Tropsch Diesel fuel, a large quantity of which the Bureau of Ships has obtained from France for engine performance studies in the U. S., Captain Latrobe said the Navy does not wish to claim that this fuel is good enough for future Diesel engines. "If industry will develop a method for rating Diesel fuels for performance," he said, "it may be determined that the Fischer-Tropsch fuel lacks constituents which are necessary to drive the high-performance engines of the future. The Diesel industry's position now is comparable with the gasoline engine industry's position some 15 years ago when iso-octane was a laboratory curiosity, he said.

"The Bureau of Ships recently sought the advice of the petroleum industry and the engine manufacturers," said Captain Latrobe, "to determine if it would be advisable to incorporate a rather interesting example of a Diesel fuel in a Navy program of testing performances of special fuels. This fuel was primarily a mixture of branched-chain paraffins, had a pour point of —85° F. and a cetane number of 58.

"About half the comments received were enthusiastic, while the other half contained objections. Those who objected maintained that the cost of manufacturing such fuel would be prohibitive as it was derived from the aluminum-chloride-catalyzed polymerization of ethylene. Insofar as the present methods of producing the fuel are prohibitive, this objection is a valid one. Yet we know from experience that industry can eventually lick any cost problem. Certainly the cost of producing isoctane did not halt its development 15 years ago."

"We are up against a much more difficult problem both in design of engines and tailoring of fuels than ever confronted the aircraft industry," he said. "The number of hydrocarbons in the Diesel fuel range is astronomical in comparison to those in gasoline. It would not be expected therefore that fuels for Diesel engines could be tailored with the same precision as those for aircraft engines. Indeed, so far as the Navy's fuels are concerned, this art may never be obtained; for other radically different prime movers may be propelling our ships before the ideal Diesel fuel is perfected."

Captain Latrobe said the program now being sponsored by the Bureau of Ships and primarily designed to lead to increases in the specific power output of Diesel engines had two features:

First, to determine what components or additives for Diesel fuels will contribute to higher performance;

Second, to determine what engine modifications will take advantage of superior special fuels.

Program for—

ADDING TO DIESEL FUEL SUPPLY

By W. E. KUHN, The Texas Co.

Presented in Discussion at Diesel Engine Session, SAE Annual Meeting, Detroit, Jan. 6-10, 1947

Various means present themselves to refiners to increase their volume of Diesel fuel output from the limited stocks available in the required boiling range. Upgrading of low quality stocks through solvent refining, or by hydrogenation, are possibilities, although at higher cost. Improver agents can be added to stocks of low cetane value but satisfactory in other respects.

Release of gas oil fractions from gasoline production requirements by production of gasoline from other portions of crude oil, natural gas or even coal is seen a long range possibility. Consumers in setting up specifications should avoid imposing limitations not justified on a performance basis.

THERE is general recognition among both users and suppliers of Diesel fuels of the growing competition for the available supplies among all users of that portion of crude oils from which Diesel fuel is produced.

A large part of the huge gasoline demand in this country is met by cracking so-called gas oils which contain an appreciable amount of material boiling in the Diesel fuel range. The use of fractions in the same boiling range for domestic heating grew rapidly in the pre-war years and there are strong indications of a considerable expansion in the field during the coming years.

More recently, a demand has developed for gas turbine and jet engine fuels which will cut into a portion of the Diesel fuel boiling range. This demand is as yet small but even in the normal progress of events may become substantially great. The effect of any greater increased military activity is obvious. Thus industry is faced with a serious problem and to intelligently cope with it a sound approach is essential. My recommendations for this approach would be as follows:

1. That, in setting up specifications for Diesel fuels, as well as the other materials employing fractions in the same boiling range, every effort be made to avoid imposing limitations which are not justified on a performance basis.

2. That careful attention be given to means for increasing the availability of these products.

The first recommendation can be carried out by cooperative effort on the part of the users and the petroleum industry. The second recommendation is pretty well up to the petroleum industry. In this regard, the following possibilities are now under active consideration:

(a) Release of gas oil fractions from gasoline production requirements by production of gasoline from other portions of

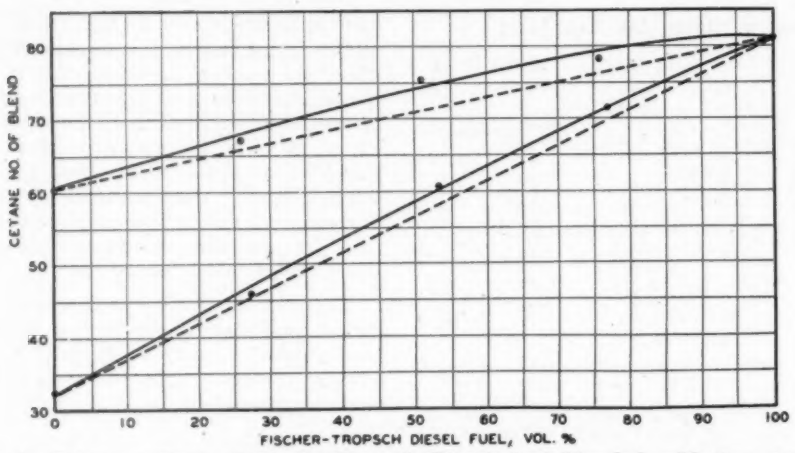


Fig. 1—Cetane ratings of Fischer-Tropsch Diesel fuel blended with two typical gas oils

crude oils, from natural gas, or from coal. Synthesis of gasoline from natural gas will soon be a commercial reality in this country.

(b) Increasing the supply of suitable material for Diesel fuels through the upgrading of stocks otherwise not of satisfactory quality. It has been established that a satisfactory Diesel fuel can be obtained at an economical though somewhat higher, cost by the solvent refining of low cetane number fractions such as are present in catalytic cracking cycle stocks. There are also indications that under certain conditions it may be practical to effect the upgrading by hydrogenation, again at an added cost.

(c) Increasing the availability of stocks meeting a given cetane number by the addition of cetane improvers to stocks of low cetane number but of satisfactory quality in other respects. It is recognized that there is considerable uncertainty as to the true significance of cetane value particularly as applied to doped fuels.

(d) Direct synthesis of hydrocarbons in the proper boiling range that will give satisfactory engine performance.

Captain Latrobe raised certain points in his paper* on which I would like to comment. In regard to a −50 pour point fuel for polar areas, engines are already available which will handle low pour point kerosine very nicely but with some loss in economy due to the lower Btu content. Most engines, however, operate best on a slightly heavier fuel. We are confident that the petroleum industry will have no difficulty in meeting the low pour point requirements with the lighter Diesel fuel.

The problem of injector corrosion is not new to us who are operating pipe line Diesels on sour crudes. Possibly an interchange of metallurgical information would be valuable.

The statement that most of the difficulties with Diesel fuels during the war could be traced to contamination emphasizes our joint responsibilities to make sure that the Diesel fuel is properly handled from the time of manufacture, through storage and finally into the combustion zone of the engine.

The value and the production of very high cetane fuels presents some interesting points. We can visualize that very high cetane fuel, by igniting very readily, burns in such a fashion as to give a more nearly constant pressure combustion cycle than does a fuel having a longer delay period, much of which burns at constant volume. The constant volume cycle which develops high pressures and temperatures is more efficient in permitting a higher ratio of expansion. Peak pressures should be lower with higher cetane fuels due to the smaller ignition lag of such fuels and, for this reason, true constant pressure combustion is more nearly approached. It is reported that with a short ignition lag, overheating and carbonization of the fuel nozzle may result and difficulties may be encountered in obtaining a good mixture formation in the last part of the injection period.

The 90-cetane number fuel referred to by Captain Latrobe was produced by the hydrogenation of carbon monoxide in a plant operating at substantially atmospheric pressure with a cobalt catalyst and at relatively low capacity. Under these conditions, which are not very economical, the amount (25-40%) of the synthetic hydrocarbon produced is in the Diesel fuel boiling range. In the commercial units now being erected in the U. S., the primary objective would be the production of high-octane motor gasoline. Only a relatively small amount of gas oil is produced in this operation and as produced the material is not particularly suited for use as Diesel fuel.

In connection with the high cetane synthetic oil produced by hydrogenating carbon monoxide at atmospheric pressure and with a cobalt catalyst, it is of interest to note that its blending characteristics, as shown in Fig. 1, are such that the cetane value of blends of this high cetane fuel with conventional petroleum fuels result in a 3 to 4 higher cetane number than would be anticipated on the basis of the cetane number of the components, or it has a blending cetane value 3 to 7 numbers higher than its actual cetane number. The higher pour characteristics of this type of synthetic fuel carry over to an abnormal extent in the blends made, as shown in Fig. 2. Pour depressants effective in the conventional Diesel fuels were tried in the synthetic fuel and the blends and were found ineffective. Fig. 3 shows the susceptibility of a blend containing 25% of the synthetic fuel to improvement with amyl nitrate as a cetane improver.

Fig. 2 (Right)—Variation of pour point of a Fischer-Tropsch Diesel fuel—naphthene base gas oil blend

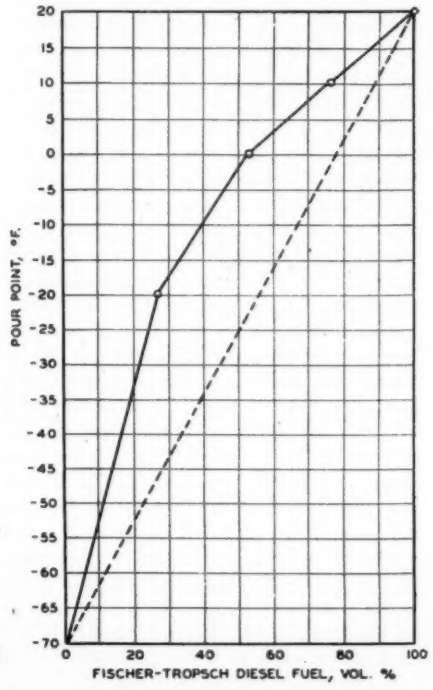
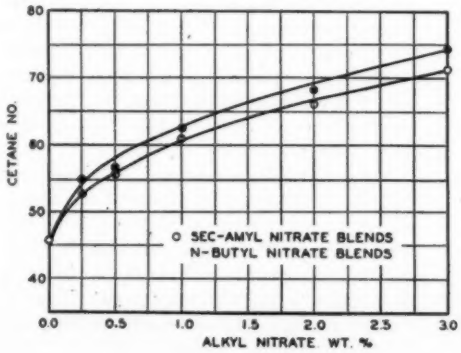


Fig. 3 (Below)—Alkyl nitrate susceptibility of a blend of 25% Fischer-Tropsch fuel and a gas oil



* "Navy Diesel Fuels," by Capt. W. C. Latrobe, Bureau of Ships, Navy Department, presented before Diesel Fuel Session, Society of Automotive Engineers, Detroit, Jan. 10, 1947. (See pg. 95 for review)

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Remove Troublesome Sulfides and Water From Unstabilized Natural Gasolines

BLACK iron sulfides and water, emulsified in unstabilized natural gasoline, were a source of considerable operating difficulty and increased maintenance expense at the Schafer (Skellytown, Texas) plant of the Skelly Oil Co.

The most serious offender was the finely divided sulfide particles, which adhered to valve parts and "froze" them, deposited in pumps and lines, plugged heat exchanger tubes, and, particularly, reduced heat transfer in reboiler and exchanger bundles.

Total unstabilized gasoline production from three other Skelly plants in the area is received by pipeline at the Schafer plant. The combined streams are processed through a fractionation battery.

Adaptation and installation of a commercial separator, combining emulsion breaking with filtration by means of a chemically treated fiber packing, is believed to have largely eliminated operating and maintenance troubles, primarily by its filtering action. Two units have been in service approximately eight months, and it is estimated that more than 75% of the difficulty has been eliminated.

Before the separators were installed, it was necessary for men to go over the raw gasoline lines at least once a week, working all valves to prevent sticking from sulfide deposits. Considerable pump trouble on the discharge side of the separators has been eliminated, and most of the water is satisfactorily removed.

Because the gasoline remains sour after being freed of water and iron sulfide, the iron sulfide still being found in plant equipment is believed largely due to corrosion which occurs after the raw gasoline has passed through the separators.

The material is so nearly colloidal in nature that it will not settle out in the conventional volume-surge tanks normally used to drop out solids and entrained water. Turbulence from pumps further increases the permanency of the dispersion. Because iron sulfide is not perceptibly soluble in water, it can ordinarily only be removed by scraping it out, burning it off (a risky procedure), or decomposing it with acid (evolving hydrogen sulfide). Some chemical cleaning agents have also been tried with varied claims for success.

Skelly decided to try two 300 gpm "Excel-So" separators, manufactured by the Warner Lewis Co., Tulsa. They were installed in parallel on the 6-in. header to which the transfer lines from the various plants connect just ahead of the depropanizer unit at the Schafer plant. One of the units handles the total stream for a week at a time, while the other is down for cleanout. Flow through each unit approximates 125 gpm.

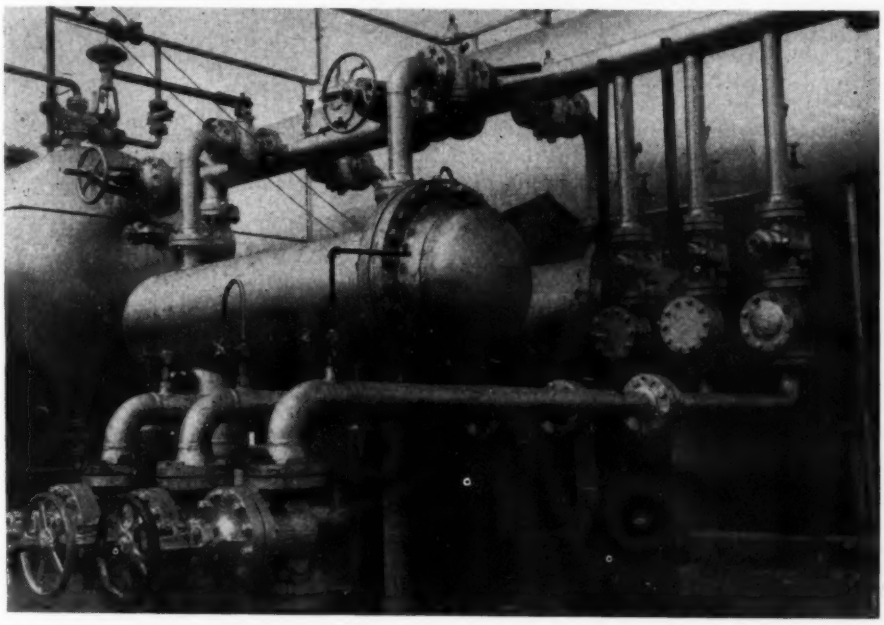
Length About Four Times Diameter

The separator consists of a large horizontal cylinder, its length about four times its diameter. It is filled for about one-third its length at the inlet end with a chemically-treated packing confined between grid-plates.

The balance of the vessel constitutes the settling chamber. At the bottom, near the outlet end, is a water-accumulator chamber equipped with an automatic dump-valve.

For cleanout, the head is removed and the packing backwashed with a steady, strong stream of cold water to flush out sulfide particles. Hot water or steam cannot be used because heat stabilizes and hardens the particles making removal impossible without tearing the packing apart. Packing is periodically renewed.

Skelly plans early installation of another separator at one of the other gasoline plants, primarily to reduce water in the transfer line to Schafer, thus minimizing winter freeze-ups.



Combination water-separator and filter assembly for removal of emulsified water and iron sulfide from unstabilized natural gasoline at Schafer plant of Skelly Oil Co. Three pipes in left foreground are terminals of transfer lines from three other Skelly plants, and connect with 6-in. header above and between separators. Inlet to vessels is at flange end; outlet at other end leading back to header, thence to surge drum in left background. Valving arrangement permits use of either unit. Transfer lines are equipped with sample taps and orifice flanges

IDEAS—Wanted!

Plant operators, foremen, superintendents—Send in your own original contributions on "how we do it around our refinery." Possible subjects could include operating shortcuts, time and money-saving gadgets, repair ideas, accident and fire prevention schemes. Include photographs, drawings, or graphs, if available.

Material submitted for publication exclusively in Petroleum Processing is paid for at the usual space rates. The idea is the thing—we'll dress up the drawings and the written information. Send your contributions to:

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Bushing Inserts Save Time and Materials In Large Valve Yoke Bushing Repairs

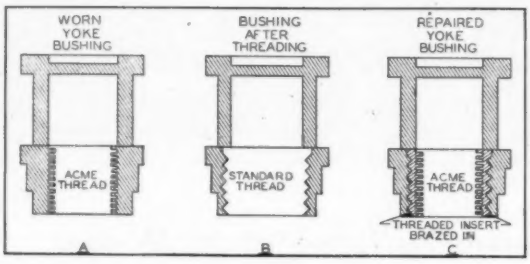

Fig. 1—Simple repair method for large valve yoke bushings in which the threads have become worn or stripped in service. A worn bushing is shown at A, bushing after threading at B. Use of a screwed-and-brazed insert bushing is shown at C. Valve stem threads are cut in after insertion

INSTEAD of making a complete new valve yoke bushing for large valves when the Acme threads have become worn or stripped, a bushing insert will do the job just as well.

A new yoke bushing requires both lathe and milling machine time. Use of the threaded insert eliminates milling machine operations, saving about one hour shop time. In addition, the small insert requires only about one-fifth as much metal as a new bushing, and can often be made from scrap material around the shop.

The old bushing is drilled out oversize and threaded with standard threads as shown at B in Fig. 1. The bushing insert is then threaded to fit, screwed into place, and brazed for permanency. The repaired bushing is then chucked in the lathe, trued up, and the Acme threads cut in the insert.

Foot-Operated Vise Saves Time, Prevents Spills in Fire Extinguisher Recharging

DID you ever try to take the cap off a 2½ gallon size, foam-type fire extinguisher by yourself? If you have, you learned what an awkward and time-consuming job it can be when you get one with a tightly-stuck cap. And, while replacing the cap, did you ever let the extinguisher accidentally get away from you and mix the two solutions?

Fireman C. Svoboda, at the Baytown refinery of Humble Oil & Refining Co., got tired of wrestling extinguishers every time they came in for recharging. So he invented a foot-operated vise to hold the extinguisher. Now one man can do the job in a jiffy without extra help, with an estimated ten minutes time saved per extinguisher, with no likelihood of damage, and with no possibility of accidentally mixing solutions.

In operation, the extinguisher is simply placed between the jaws of the vise, as shown in the photograph and clamped firmly by stepping down on the foot pedal.

The upright handle has a saw-toothed projection on one side, into which the piece of angle iron on the side of the pedal can be caught to act as a ratchet. The pedal is released by stepping down and sidewise on it enough to free it from the catch. The upright handle also serves to steady the operator when he is clamping or freeing the extinguisher. The vise jaws are padded to help get a tight grip without excessive pressure and to prevent damaging the extinguisher case.

The vise was built from scrap metal and stout two-by-fours. In the previous method, the wrench used to get a grip on the smooth cap often slipped, denting or marring the extinguisher. Often the hose connection was knocked off at the same time.

Fire extinguisher vise built from scrap metal and wood saves time, spoiled tempers, and prevents damage to the extinguisher or accidental mixing of solutions during handling. Foot pressure on pedal at left closes padded clamps tightly around extinguisher casing

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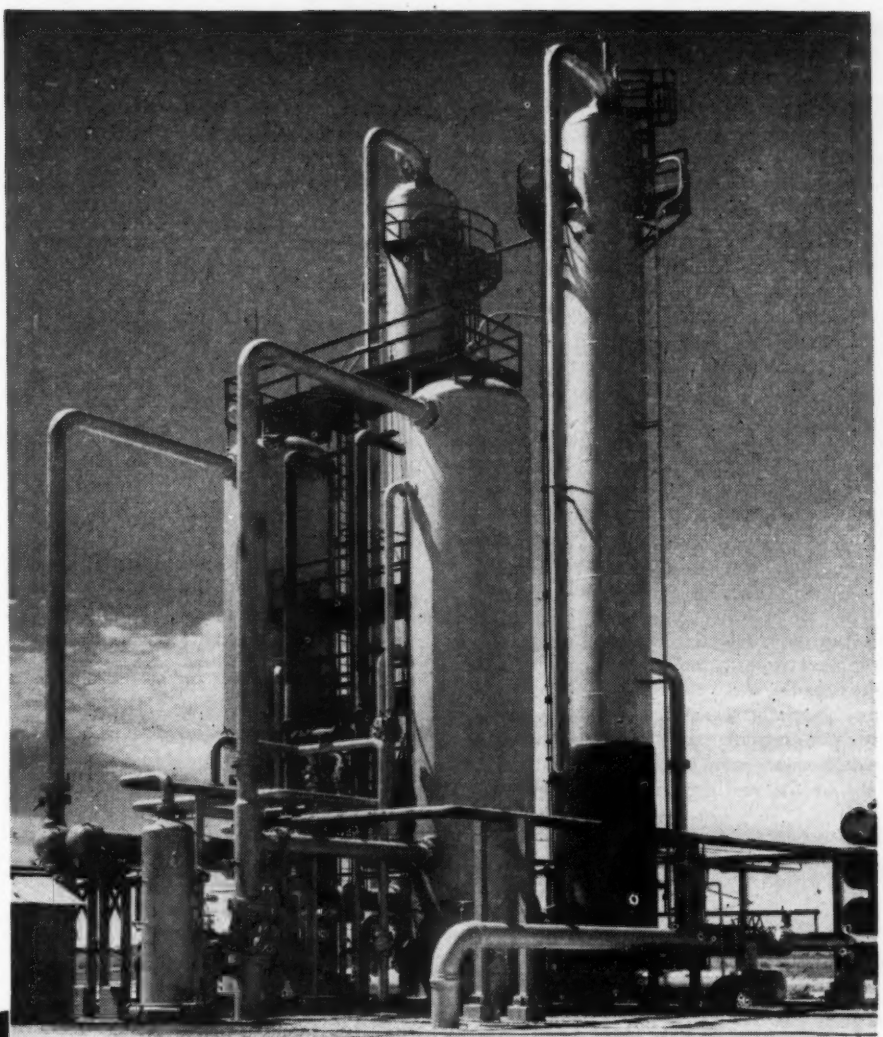

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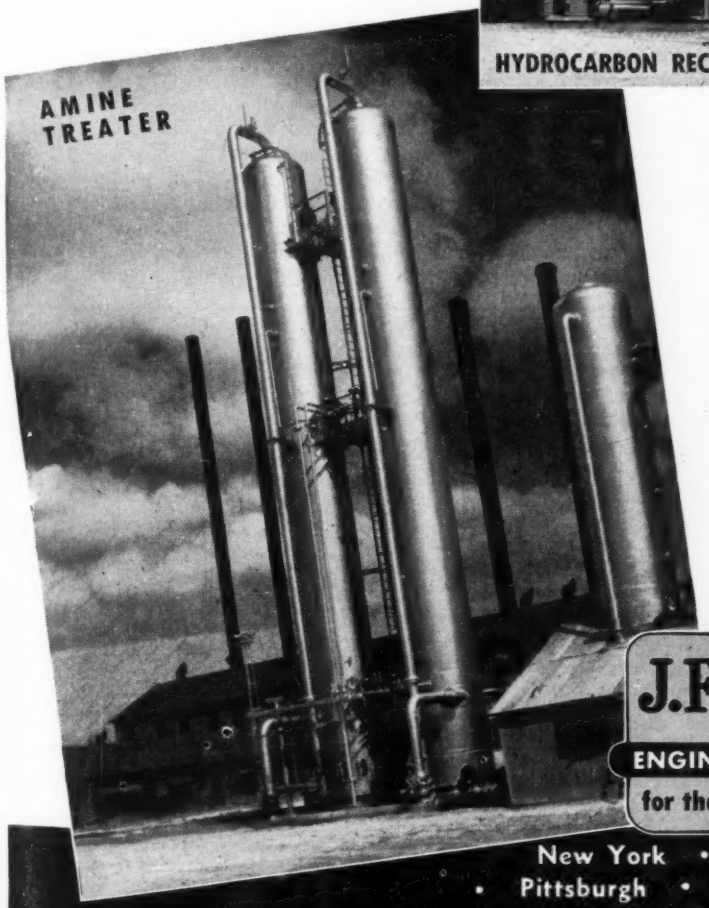

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Steam Hose Connection Permits Frequent Gas Burner Cleaning Without Shutdown

THE job of dismantling gas burners on heaters or cleaning can be reduced in frequency and a better job of heating done if the burners are steamed out occasionally. At Humble Oil & Refining Co.'s Baytown plant, burners on the heaters of the Fluid Catalyst Cracking units have been provided with a steam-hose connection to the gas lines serving the individual burner. To clean a burner, the gas supply is turned off at the valve, hose is connected from the steam header to the burner, and steam injected instead of gas. When the burner is cleaned, steam is shut off, gas turned on and ignited.

This procedure cleans the orifice of the burner as well as the other parts, inspectors report, making it unnecessary to dismantle the valve. It also permits more frequent cleaning of the burner, does not require shutting the furnace down, and reduces requirement for eventual dismantling and cleaning.

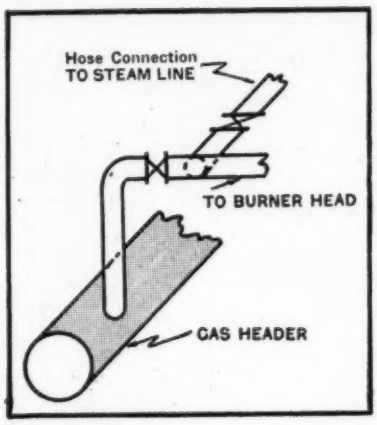


Fig. 2—Arrangement for steam-cleaning of gas burner without shutting down heater. Spud carrying valve and steam hose connections is welded to gas supply line between valve and burner.

Temperature of Feedwater for Desalter Controlled with Steam Pressure Regulator

FEEDWATER for a desalting unit is heated automatically with wasted exhaust steam in a unit devised and built at a midwestern refinery. Constructed from salvaged materials, the device has been in continuous service for eight years.

A diagrammatic sketch of the unit is shown in Fig. 2. Between 500 and 1000 gals./hr. of water are heated in the equipment and fed to the desalter at the constant required conditions of 217° F. and 3 psig; this can be varied, however, within range of the controls. Incoming water from cooling towers is between 100° and 110° F. Incoming steam is saturated exhaust steam at 50 to 55 psi (300° F.).

Operation of the device is explained as follows: Steam tables show that water at 217° F. generates approximately 3 psi. The principal working technique is that the steam regulator has to inject sufficient steam to raise the water temperature until steam at 3 psi is generated. The system is enclosed except for the ¾-in. vent. This size vent is used to prevent excess waste of steam which is nominal through the ¾-in. line at 3 psi.

Since the water temperature is constant for any given steam pressure, the water temperature is indirectly maintained constant by controlling the pressure. Any change in water flow instantly changes the requirements of steam for heating. Thus the steam pressure will increase or decrease accordingly. Because the steam injection is controlled so as to maintain a given 3 psi., variable water flows do not change the temperature.

The unit was installed to overcome some of the variables in operation of the desalting unit. It was so successful that a similar method of control was developed for treating boiler feedwater by simply installing the steam pressure control valve for injection of steam. This boiler house unit treated water for three 500 hp boilers operated at about 200% rating.

Proper Use of Steam Reduces High Temperature in Preheater

IN PLANTS where exhaust steam is used for agitation of liquid in stills and columns, and live steam must be used for make-up, the live steam should be injected into the exhaust steam before it enters the preheater. If injected after preheating, the preheater effluent will be cooled below the desired temperature or preheat temperature must be increased. The live steam, at a higher temperature than exhaust steam as well as at greater pressure, will be cooled upon ejection into exhaust steam because of the pressure drop. This will throw a slightly greater load on the preheater, but will eliminate need for preheater operation at a higher temperature to secure desired temperature for agitation steam. In this case heat is more important than volume.

Photo at left shows installation of unit. Insulated lines and housing at right of vessel constitutes level control for incoming water

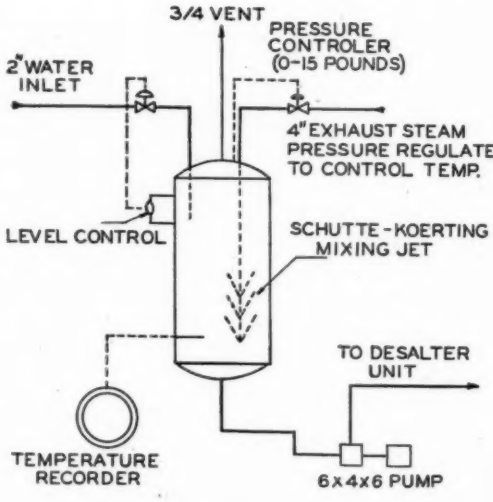
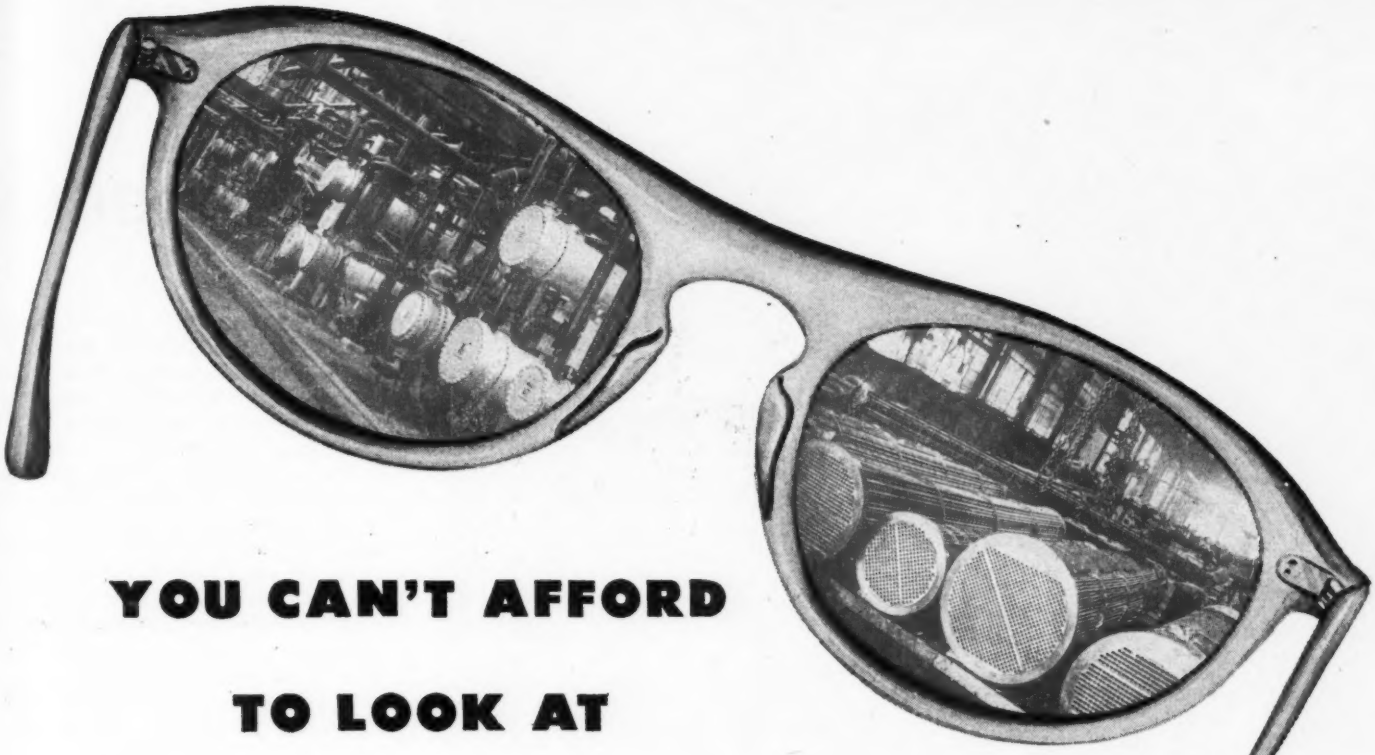


Fig. 3 — Diagrammatic sketch of device for automatic heating of feedwater for desalting unit. Controlling pressure of incoming steam automatically controls temperature of feedwater



YOU CAN'T AFFORD TO LOOK AT HEAT EXCHANGE EQUIPMENT

Through ROSE *colored glasses*

The very simplicity of the theory of transferring heat from one fluid to another without physical contact merely serves to underscore the numerous difficulties which must be overcome in its practical application.

Some of the heat exchange equipment produced by Kellogg involved super-pressures of from 5000 pounds per square inch and temperatures of 1100°F to high vacuum service and below zero temperatures of the order of liquid oxygen. Types of exchangers included gas to gas, gas to liquid and liquid to liquid, vapor condensers and waste heat boilers.

Over 4300 heat exchange units were produced by Kellogg during the war years.

Many novel and advanced techniques were developed by Kellogg during this period, the benefit of which are now available to refiners.

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Photos courtesy Chicago Bridge & Iron Co.

General view of the three 4500-bbl. cone-bottom tanks installed at the Baton Rouge refinery of Standard Oil Co. of N. J. to remove oil from silt by aeration. This unit has effectively solved the refinery's problem of disposing of oil-containing silt

Inexpensive A

AN EFFECTIVE and inexpensive means of washing oil from the silt that collects in the separators at its Baton Rouge refinery has been devised by engineers of the Standard Oil Co. of N. J. (Louisiana Division.)

The cooling and process water used in the refinery is obtained largely from the Mississippi River, and contains a considerable amount of silt. During processing operations and in the sewers of the plant this silt becomes saturated with oil, and is eventually deposited—with the entrained oil—in the bottom of the refinery's oil-water separators.

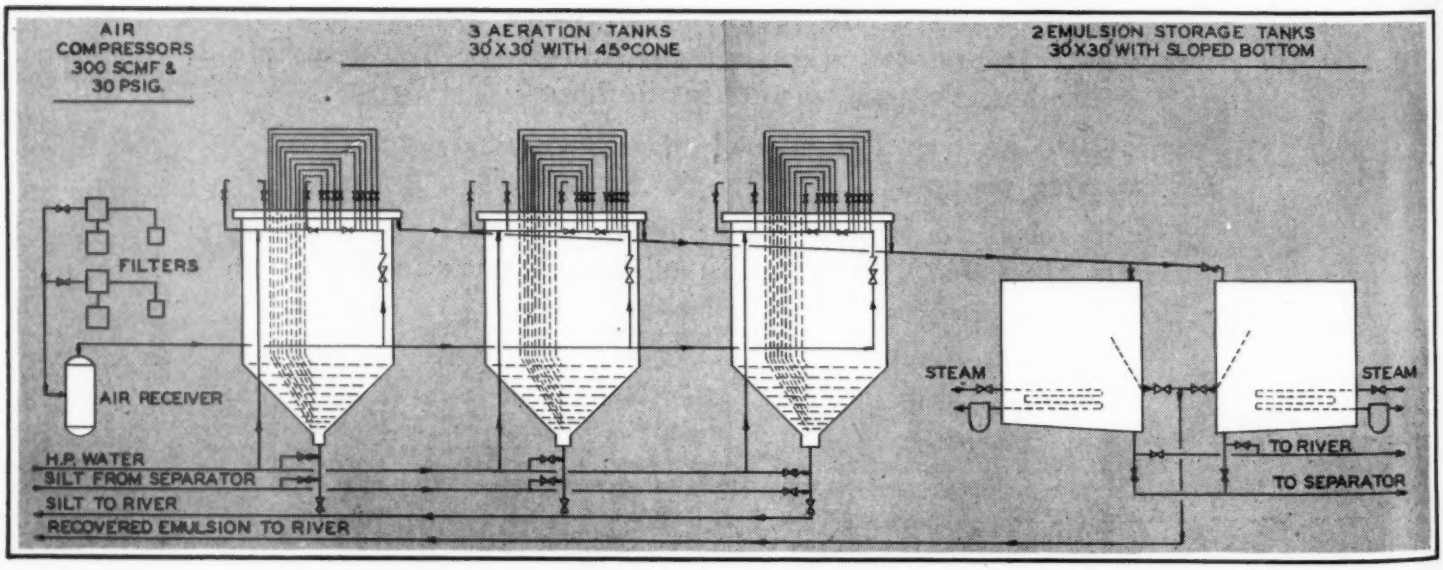
In past years the deposited material, containing 20-30% oil, was washed into the river. Now, however, it is treated in a special Silt Treating Unit, designed by Standard's engineers and built by Chicago Bridge & Iron Co.

Aeration Promotes Separation

The silt treating equipment consists essentially of three 4500-bbl. cone-bottom tanks, 30 x 30 ft., in which the silt is aerated to promote separation of the oil, which rises to the top and is removed.

In operation, silt is pumped to one of the tanks, diluted with water to the extent that the mixture contains 10 to 15%

Fig. 1—Flow diagram of Standard's Silt Treating Unit, which handles approximately 500 bbl. of silt daily and recovers 60 to 80 bbl. of oil. The silt, which settles out in the oil-water separators and contains 20-30% entrained oil, is pumped into the tanks, diluted with water and blown with air. It is the aerating process which causes the oil to separate and rise to the surface



Aeration Tanks Handle Disposal Problem

silt, and then thoroughly agitated with air for 3 to 5 minutes. The air is supplied at 30 psi pressure by two 300 cfm compressors, and is admitted through a 2 x 30 in. carborundum diffuser tube in the cone at the bottom of each tank. A ¼-in. globe valve is used for adjusting the rates.

Oil Removed by Flooding

After the initial agitation, the contents of the tank are allowed to settle for several hours with an extremely small flow of air coming through the diffusion tube in the cone. After this, the oil and emulsion which have risen to the surface are flooded over weirs near the top of the tank into two open rundown tanks of 3800 bbl. capacity each. Water for flooding the tank is admitted through a 2-in. line about 3 ft. under the surface.

This whole cycle is then repeated until no appreciable oil rises to the surface, after which the contents of the tank are dumped on the low land behind the river levees. Usually 18 to 24 hrs. are required for each batch of silt. Although the silt still shows 6 to 10% oil, it will bleach out on the banks whiter than the river sand in a few days' time.

Recover 60-80 b/d of Oil

Fig. 1 shows the flow plan of the unit as built. In actual operation it has been found that all the air needed can be supplied by the diffuser tubes, so that the pipe sprays are not required.

The oil and emulsion which are drawn off the aeration tanks are allowed to settle at about 120° F. in the two rundown tanks. After settling, the water is drawn off and the remaining emulsion is treated in the regular refinery emulsion unit. About 60 to 80 bbl. of oil are recovered daily from approximately 500 bbls. of silt.

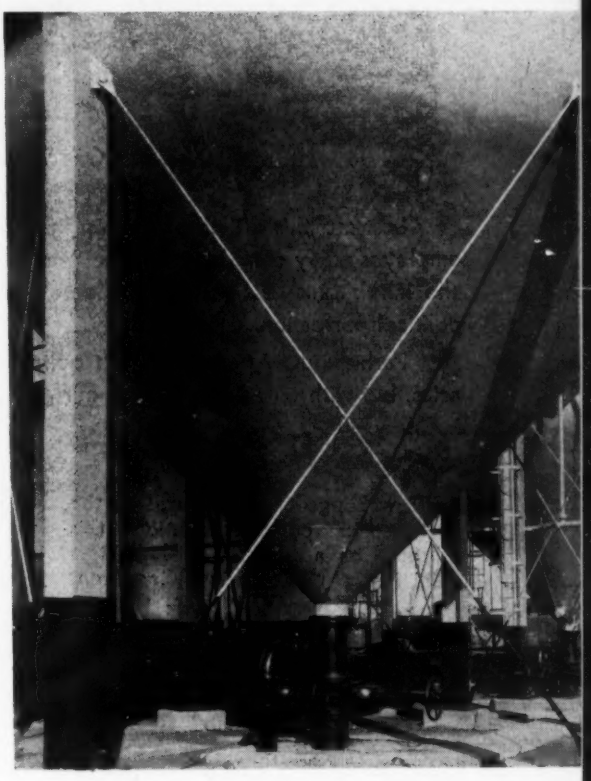
The emulsions which have not broken when settled are pumped through a preheater, heated to 180-200° F., and discharged through an orifice mixer into one of two 20,000-bbl. emulsion treating tanks. Chemical treating solution (Tret-O-Lite L-13693) is added to the emulsion just before the preheater at the rate of 4-12 gal./1000 bbl. Then, after the preheater and before the orifice mixer, a 10% soda ash solution is added at the rate of 600-700 gal./1000 bbl. The oil enters the treating tank about 6 ft. up in the tank, just under the heating coils.

The treated emulsion is allowed to settle in the tank until samples taken from sample lines every two feet on the side of the tank indicate that some of the oil is below 1% B.S.&W. This oil is pumped into refinery rerun unit feed tanks by adjusting the swing suction. The rest of the material in the tank is allowed to settle for a longer period, or retreated, or additional emulsion is treated into the tank under this material.

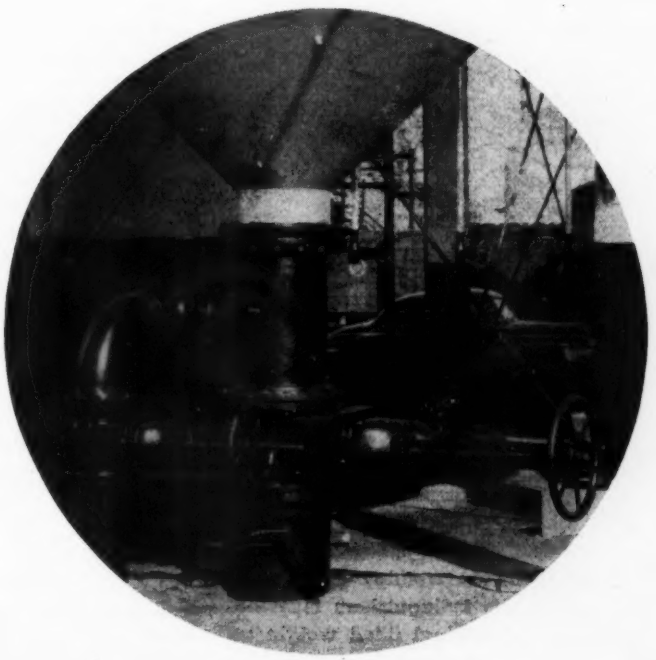
40-50% Yield from Treatment

The dark water and silt which settles out of the oil is diluted with water, aerated in the aeration plant, and released into the water going from the separators to the river. A yield of about 40 to 50% oil is obtained from the chemical treatment.

We acknowledge with thanks the assistance of Dr. J. E. Miller, head of the Oil Conservation Dept. of the Standard Oil Co. of N. J. at Baton Rouge, and of Milo E. Smith, editor of *The Water Tower*, Chicago Bridge & Iron Co., in making the above information and photographs available.



Cone-section of one of the three aeration tanks, showing connections for admitting and removing silt. Each of the tanks is 30 ft. in diameter, with a 30-ft. straight section above the 45° cone, and has a capacity of 4500 bbl.



Close-up of the piping and valving arrangement of the tank shown above. Silt from the refinery oil-water separator is pumped in through the 8-in. line coming up at the left and water through a 6-in. line (just barely visible). The large 16-in. line coming down directly from the cone is for removing the washed silt

No Welding Injuries or Fires At World's Safest Refinery

By FRANK J. SLUZE, Safety Director
Ashland Oil & Refining Co.

Last month's article on Utopia Refinery told of a mythical plant where employes enjoy complete absence from injuries and fires much the same as the inhabitants of Sir Thomas Moore's mythical island enjoyed social and political perfection.

Perhaps utter perfection isn't quite possible in this world of real refineries, but with that perfection as our goal, we continue our tour of UTOPIA Refinery.

THE welding department will be the object of our investigations this month in Utopia refinery, so let's start with an inspection of the welding shop.

Notice that floors and work benches are kept free of any material except that which is necessary for the work at hand.

We find that all welding carriages are equipped with carbon tetrachloride fire extinguishers. Let's try one to see if it is in good operating condition. Yep—it's OK—full of liquid—nozzle not corroded shut—piston not leaking—and it throws the proper stream.

While we're at it, let's inspect the carbon dioxide extinguishers too. Uh-huh!—the inspection tag shows original weight was 48 lbs.—reweighed a month ago—still 48 lbs.—OK! The seal being intact shows that it hasn't been used or tampered with.

We see that all these extinguishers are hung on wall brackets within easy reach at all times and not obstructed by trash drums, scrap, or other materials. Above the extinguisher is a sign explaining how to use it. Good idea—a man's memory tends to get a trifle hazy between verbal instructions from the foreman.

To stay in tip-top working order, carbon dioxide fire extinguishers must be maintained at original filled weight at all times

Over there is a welder at work. He has completely surrounded himself with a curtain or shield so as to cut off the harmful arcs from persons in that vicinity. Notice also a sign on the shield reading "DANGER—DO NOT WATCH ARC." We can't help observing, too, that men working near this welder have provided themselves with dark colored spectacles (flash goggles) to keep out harmful rays.

Oh! Oh! Just as the welder lifted his hood a piece of scale flew toward his eyes. No harm done, however. He was wearing a second pair of chipping goggles under the hood.

He's finished the job and is putting the work on the bench. Wonder what he's reaching into his pocket for. Oh! He just took a piece of chalk out and is marking "Caution—do not touch—hot metal" on the hot piece of pipe. A very good way to prevent nasty hand burns.

Lines Are Marked

Let's examine the oxygen and acetylene cylinders. Notice they are securely chained to the wall. The lines are identified by distinctive colors—red for acetylene and green for oxygen; an excellent precaution againt mix up.

Outside the shop we find the empty cylinders stored on the wharf—chained to prevent accidental falling, and capped and marked empty. Full cylinders are stored on another wharf—also securely chained in place, and out of the rays of the sun. The sun's heat could cause a cylinder to overheat and rupture, you know.

Welding cables are in good condition, too. No bare spots—no bad kinks—no ragged edges on the insulation.

Over there we see a welder squirming into a leather suit (pants and jacket)—wonder what for? In answer to our query, he informs us that he is going to weld on a tray in a bubble tower. We all know the space between trays is only about 30 inches; therefore, he must equip himself with fire resistant clothing. He is also wearing leather gloves of sufficient thickness, free of grease and oil, and free of holes.

We ask him if it's safe to do "hot work" inside the tower. He shows us a "Hot Work Permit" signed by the foreman in charge and the safety engineer, vouching for its safety.

He Does It Properly

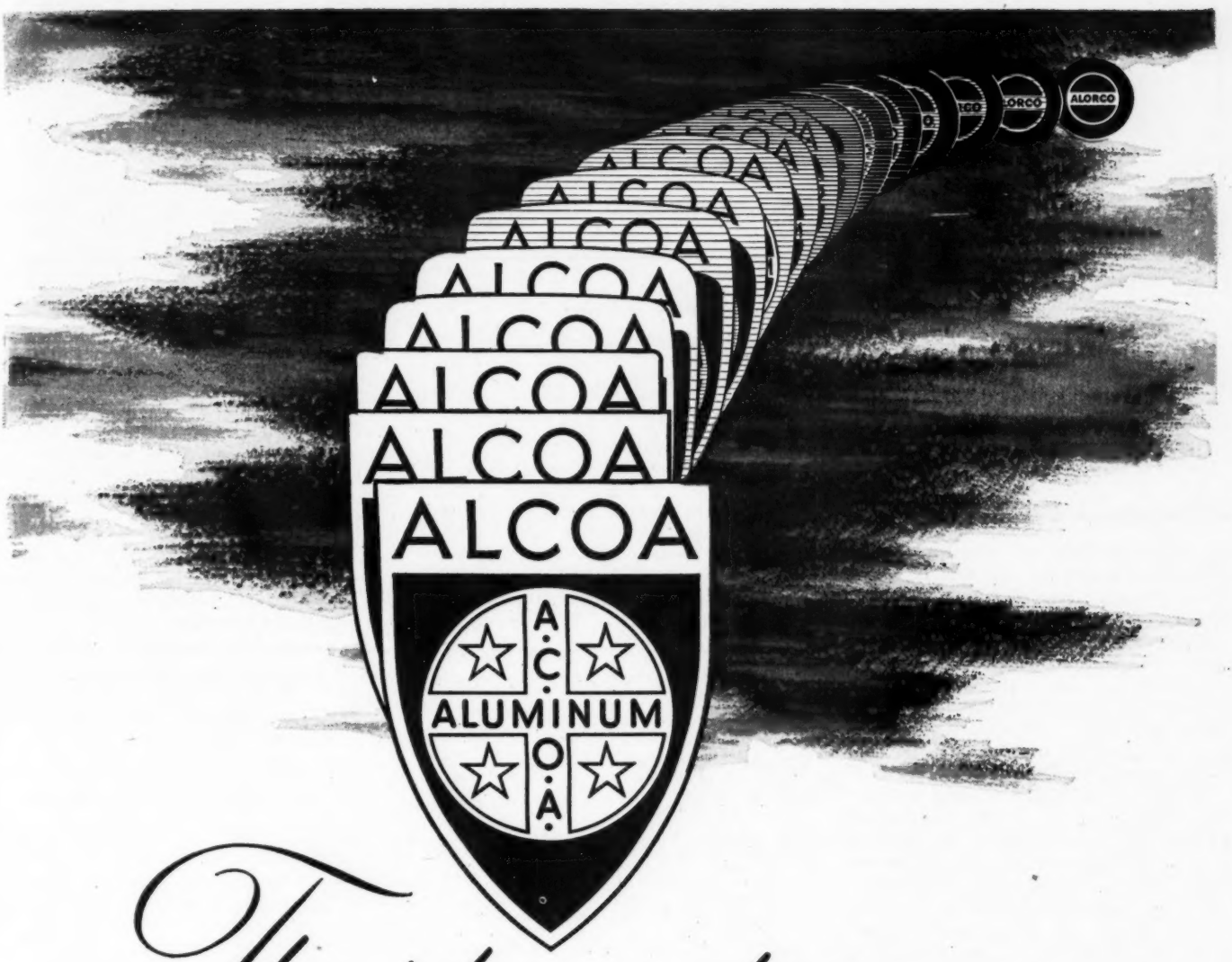
Following this welder to the Cracking plant, we observe that he has called the No. 1 operator over and asked him permission to plug his welding cable into a nearby power receptacle. The operator first inspects the surrounding area. Being satisfied that it is safe (free of gas, vapor, or oil) he gives the welder the OK.

Now the welder is about to fasten the ground. Wonder where he is going to attach it? Very good! He fastens the clip to the vessel on which he's going to work—the shortest and most efficient return.

Chipping done during a welding job requires extra eye protection in addition to welder's hood. Welder wears light weight goggles under hood at all times

We also notice that on the power side of the welding machine the cable has been strung overhead so as to eliminate any shock hazard or traffic abuse.

Over there another welder is going to a job on a railroad tank car. He explains that in addition to his "Hot Work Permit" he must protect himself against switching accidents. For that reason he places his own "Blue Flag" stop sign to warn switching crews that he is working on a car on that siding or spur. He also notified the traffic supervisor of the refinery that he was going to work on the car.



There's been a change

The same top quality Aluminas and Fluorides—produced by the Aluminum Ore Company, and for years sold under the "Alorco" brand name and trade-mark—now carry the ALCOA trade-mark. They will be marketed exclusively by the Chemicals Division of Aluminum Company of America.

Just as the ALCOA shield has long been the symbol for the best in aluminum—so now look to it for the best in aluminas and fluorides.

ALCOA ALUMINAS are versatile chemicals. They are used as hard-biting abrasives . . . as high temperature refractories . . . as catalyst carriers . . . for drying gases and liquids . . . and employed in dozens of other ways. More likely than not, the spark plug "porcelains" in your car are made of *Alcoa Alumina*.

ALCOA FLUORIDES are used in many ways . . . for laundry compounds . . . for preserving wood . . . and as *Alcoa Cryolite Insecticide* to protect both farm and orchard crops. Let us tell you how these Alcoa products can serve you. Call your nearest Alcoa sales office, or write ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 1780 Gulf Bldg., Pittsburgh 19, Pennsylvania.

ALCOA *Aluminas and Fluorides*

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Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Developments disclosed in the patents reviewed below include:

The dehydrogenation of some cyclopentane fractions into cyclopentene.

Shell's use of inhibitors for aluminum chloride corrosion.

Utilizing a radioactive catalyst, carnotite, for a unique cracking process.

A new deicing fluid.

Cyclopentene from Cyclopentane

A FEW oil firms are actively engaged in developing the new field of naphthenic chemicals from petroleum raw materials. Cyclopentene may become a valuable raw material for synthesis of special solvents such as cyclopentanol, cyclopentanone, etc. However, it does not exist in gasoline in appreciable quantities, although cyclopentane fractions may be obtained which might be dehydrogenated to cyclopentene.

In its U. S. 2,412,936, Phillips Petroleum Corp. discloses a dehydrogenation process wherein hydrogen is recycled to the dehydrogenation zone and a polymerization step is included to remove and recover cyclopentadiene formed.

According to Fig. 1, cyclopentane feed is introduced into line 1, mixed with recycle hydrogen from line 5, and passed into catalytic dehydrogenation zone 2 where cyclopentene, cyclopentadiene and hydrogen are formed. Part of the hydrogen is bled off through line 4 while the remainder is recycled through line 5 in separator 3. In fractionator 6, cyclopentene and cyclopentadiene are taken overhead through line 8, while cyclopentane is recycled through line 7. The unsaturates from line 8 are passed through polymerization zone 9 wherein cyclopentadiene is dimerized.

In fractionator 11, cyclopentene is drawn off through line 12 while the diene dimer is depolymerized in vessel 14 to cyclopentadiene which is then recycled through line 15 to be mixed with the feed.

Table 1 shows how hydrogen recycling increases the cyclopentene content of the effluent gases without appreciably altering the conversion.

TABLE 1—Effect of Recycling Hydrogen in Conversion of Cyclopentane to Cyclopentene

	Without hydrogen	With hydrogen
Hydrogen added, gas vol. per cent	None	73
Pressure, atmospheres	1	1
Average temperature, °F.	1,048	963
Cycle length, min.	30	30
No. of cycles	1	1
Space velocity (vol./vol. cat./hr.)	468	630
Effluent analysis, per cent by weight:		
Hydrogen	1.9	0.3
Light gases (C_1-C_5)	1.4	4.8
Cyclopentene	8.3	11.9
Cyclopentadiene	8.3	9.1
Cyclopentane	70.4	71.6
Deposit on catalyst	9.7	2.3
Total	100.0	100.0
Cyclopentane conversion, per cent	29.6	28.4
Weight ratio, cyclopentene/cyclopentadiene	1.0	1.31

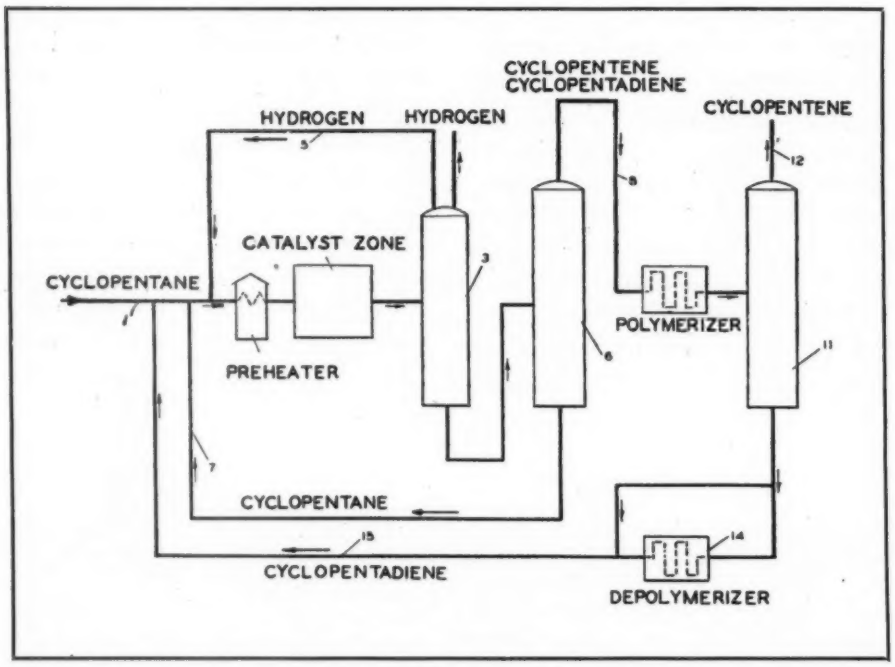


Fig. 1—Flow diagram of process for dehydrogenating cyclopentane to cyclopentene in which hydrogen formed in the reaction is recycled, resulting in a marked decrease in catalyst deposit and an increase in cyclopentene yield (U. S. 2,412,936)

Inhibiting Corrosion By Aluminum Chloride

ALUMINUM chloride is now becoming a common chemical in the refinery, with the advent and growth of isomerization, alkylation, reforming, and other hydrocarbon conversion processes. One difficulty, encountered particularly with organo-aluminum halide complex catalysts which often seriously detracts from the advantages otherwise inherent in their use on a practical scale, is their corrosive nature, especially with respect to steel and other ferrous metals.

Shell Development Co. describes (in its U. S. patent 2,411,483) the use of inhibitors for minimizing such corrosion, these inhibitors being selected from the metals of groups IV and V of the periodic table, the elements arsenic and antimony being considered metals in this case.

To show the adverse effect of dissolved iron upon isomerization, an example is given wherein a dimethyl-cyclopentane-containing fraction of straight run gasoline having a boiling range of 85°-98° C. was treated with a catalyst consisting of an aluminum chloride-toluene complex at 80° C. for 17 min. contact time with a

catalyst-hydrocarbon ratio of 1:3, and hydrogen chloride in amount of 0.1% by weight was added to the charge. The operation was discontinued when catalyst activity had dropped to 50% of the equilibrium conversion of dimethyl-cyclopentane of methyl-cyclohexane. Under these conditions, 106 gallons of the hydrocarbon charge were treated per pound of $AlCl_3$ in the catalyst.

In the second operation, a separate portion of the same feed was treated under identical operating conditions with a separate portion of the same catalyst in which iron in an amount of 6% by weight of the catalyst had been dissolved. The amount of hydrocarbon charge treated per pound of $AlCl_3$ in the catalyst in the second operation amounted to only 78 gals.

The halides of the inhibitor metals are added in concentrations of 0.05-3% of the organo-metal halide complex catalyst. The halides of antimony and titanium and arsenic oxide have been found suitable. Table 2 shows the corrosion rate encountered when such operations are run under otherwise comparable conditions, with and without various inhibitors.

TABLE 2—Effect of Inhibitors in Reducing Corrosion by Aluminum Chloride (Shell—U.S. 2,411,483)

Catalyst	Inhibitor per cent of cat. by wt.	Temp., ° C.	Contact time, hrs.	Corrosion rate mils per year: Low carbon steel	Corrosion rate mils per year: 5% Ni steel
P-196 A	None	80	0-20	3,530	1,660
P-201 A	0.2% $SbCl_3$	80	0-24	7	6
		80	24-89	6	11
P-205 A	0.4% $SbCl_3$	80	0-21	6	13
		80	21-88	9	18
P-199 A	4% $SbCl_3$	80	0-23	6	5
		80	23-47	8	8
P-228 B	None	80	0-25	5,600	....
P-233 B	1% $TiCl_4$	80	0-24	35	....
		80	24-89	25	....
P-247 B	0.1% As_2O_3	80	0-24	11	....
		80	24-87	4	....
P-251 B	0.3% As_2O_3	80	0-137	0.6	....
P-259 B	0.3% As_2O_3	100	0-24	24	....
P-237 B	1% $AsCl_3$	80	0-24	1	....
		80	24-136	3	....
P-198 C	None	80	0-23	2,140	....
P-260 C	0.3% As_2O_3	100	0-24	2	....
	0.3% As_2O_3	100	0-24	2	....
P-262 A	1% Fe (as Fe_2O_3)	80	0-24	2,250	....
P-263 A	1% Fe (filings)	80	0-24	1,500	....
P-234 B	1% PCl_3	80	0-24	2,630	....

Radioactive Carnotite Ore Used in Cracking Process

NOT so long ago, there were some announcements(1) in the press concerning a unique cracking process developed by Rose and owned by Potomac Hydrocarbon Process Corp., utilizing a radioactive catalyst such as carnotite ore.

A patent recently issued to Potomac (U. S. 2,412,837) discloses some information on the process and the use of a "catalyte" having the composition:

Material	Pts. by wt.
Natural phosphate rock	10-50
"Floridan" clay	10-50
Zinc phosphate	5-30
Barium chloride	5-30
"Fire bond"	10-40

The carnotite added was 25%-100% by wt. of the total weight of all other ingredients. This catalyst is said to have been covered in a patent(2) issued in 1939.

In the process disclosed in the recent patent, liquid hydrocarbon feed is pumped to a cooling chamber, where it meets steam of compressed recycle gaseous hydrocarbons. The total mixture is then passed through heated tubes (at 700°-1200° F.) containing the "catalyte" specified, thence into a "soaking" chamber, also filled with "catalyte." The pressure is quickly released through an expansion valve from 700-1000 psi. to 150 psi., after which the product enters a stabilizer.

No operating data are given and there is nothing to indicate any superiority over the usual thermal or catalytic processes.

References

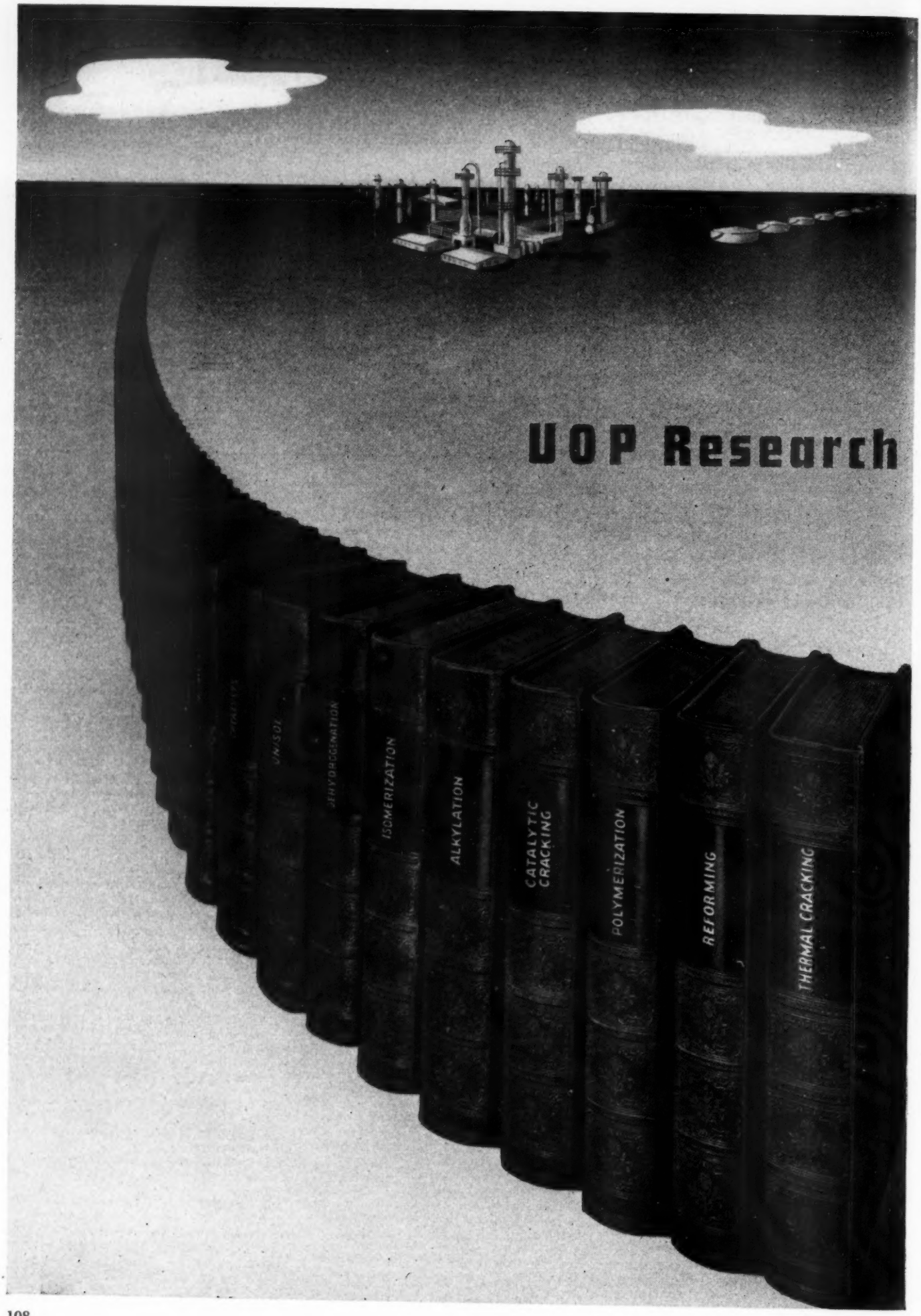
(1) Gaylor Technical Survey, 1946, p. 480, 546, 560.
(2) U. S. Patent 2,173,376.

De-icing Fluid

A DE-ICING fluid recently patented by Shell Development Co. (Canadian 434,085) contains 35 parts by volume of ethylene glycol, 35 parts diacetone alcohol, 30 parts water and small amounts of beta naphthol and sodium nitrite.

Selected Patents of the Month

U.S. 2,411,275-6 (Univ. Oil Prods.)—Organo-polysulfide rubber.
U.S. 2,411,307 (Shell Dev. Co.)—Stabilized aromatic amines.
U.S. 2,411,346 (Sinclair Refining Co.)—Nitrile refining.
U.S. 2,411,437 (Union Oil Co.)—Azeotropic distillation.
U.S. 2,411,453 (DuPont)—Apparatus for making alkyl lead compounds.
U.S. 2,411,483 (Shell Dev. Co.)—Corrosion inhibition in catalytic conversion with antimony halides.
U.S. 2,411,582 (Standard Oil Development Co.)—Aviation fuel containing spiropentane.
U.S. 2,411,583 (Stan. Oil Dev. Co.)—Compounded lubricating oil.
U.S. 2,411,586 (Texas Co.)—Barium salts of cyclic-aliphatic ether alcohols.
U.S. 2,411,587 (Stand. Oil Dev. Co.)—Anti-friction bearing grease.
U.S. 2,411,593 (Shell Dev. Co.)—Corrosion preventive comprising hydrocarbon fraction containing hydrocarbon fraction and finely dispersed organic monobasic acid of 10-60 carbon atoms.
U.S. 2,411,599 (Stand. Oil Dev. Co.)—Olefin-methacrylate interpolymer.
U.S. 2,411,671 (Gulf Oil Corp.)—Alkyl alkylene diphosphate salt defoamer for oils.
U.S. 2,411,785 (Phillips Petr.)—Furfural solvent extraction.
U.S. 2,411,799 (Univ. Oil Prods.)—Dealkylation of alkyl cyclic compounds.
U.S. 2,411,819 (Shell Dev.)—Improving oil solubility of sulfonates.
U.S. 2,411,820 (American Cyanamide) — Silica containing catalysts.
U.S. 2,411,822 (Union Oil Co.)—Liquid phase dimerization.
U.S. 2,411,823 (Union Oil Co.)—Unsaturated ketones by reacting olefins with acid anhydride.
U.S. 2,411,958-9 (duPont)—Removing copper from petroleum product with sodium thioglycolate, etc.
U.S. 2,411,961 (Shell Dev. Co.)—Catalyzed abnormal addition reactions (also 2,411,983).
U.S. 2,411,962 (duPont)—Esters from acetylene.
U.S. 2,411,992 (Universal Oil Prods.)—Paraffin alkylation.
U.S. 2,411,996 (Univ. Oil Prods.)—Catalytic conversion.
U.S. 2,412,010 (Phillips Petroleum Co.)—Toluene purification.
U.S. 2,412,012 (Universal Oil Prods.)—Aldehydes and acetals from halo hydrocarbons.
U.S. 2,412,014 (Godfrey L. Cabot, Inc.)—Formaldehyde from natural gas oxidation with air and NO_2.
U.S. 2,412,082 (Gabriel)—Cutting Oil.
U.S. 2,412,096 (Lion Oil & Ref'g)—Oxidation-cracking to give aromatics.
U.S. 2,412,131 (Ohio Oil Co.)—Cutting oil.
U.S. 2,412,143 (Socony-Vacuum Oil Co.)—Separation and recovery of soluble catalyst.
U.S. 2,412,152 (Univ. Oil Prods.)—Contacting finely divided solids with fluids.
U.S. 2,412,214 (Standard Oil Development Co.)—Synthetic rubber.
U.S. 2,412,220 (Phillips Petroleum Co.)—Treating fluorine containing hydrocarbons.
U.S. 2,412,229 and 2,412,230 (Universal Oil Products Co.)—Alkylation.
U.S. 2,412,359 (Stanolind Oil and Gas Co.)—Analysis method.
U.S. 2,412,371 (Sinclair Refining Co.)—Gasoline.
U.S. 2,142,437 (Phillips Petroleum Co.)—Unsaturated Nitriles.
U.S. 2,412,550 (Pure Oil Co.)—Ethyl halides.
U.S. 2,412,557 (Petrolite Corp.) — Lubricating Oils.
U.S. 2,142,647 (Standard Oil Development Co.)—Treating hydrocarbons.
U.S. 2,412,667 (Standard Oil Co. (Ind.))—Sludge coking.
U.S. 2,412,679 (Standard Oil Co. (Ind,))—Preparation of organic sulfonates and sulfonyl chlorides.
U.S. 2,412,696 (Standard Oil Development Co.)—Process for regeneration of cracking catalysts.
U.S. 2,412,708 (Petrolite Corp.) — Lubricating Oils.
U.S. 2,412,823 (Phillips Petroleum Co.)—Furfural recovery.
U.S. 2,412,828 (The Texas Co.)—Preparation of aromatic hydrocarbons from hydrocarbon mixtures.
U.S. 2,412,863 (Socony-Vacuum Oil Co.)—Circulation and contacting of acid catalysts.
U.S. 2,412,880 (Phillips Petroleum Co.) Azeotropic distillation of butadiene and 2-butene.
U.S. 2,413,106 (The Texas Co.)—Alkylation.
U.S. 2,413,121 and 2,413,122 (Standard Oil Co.)—Greases.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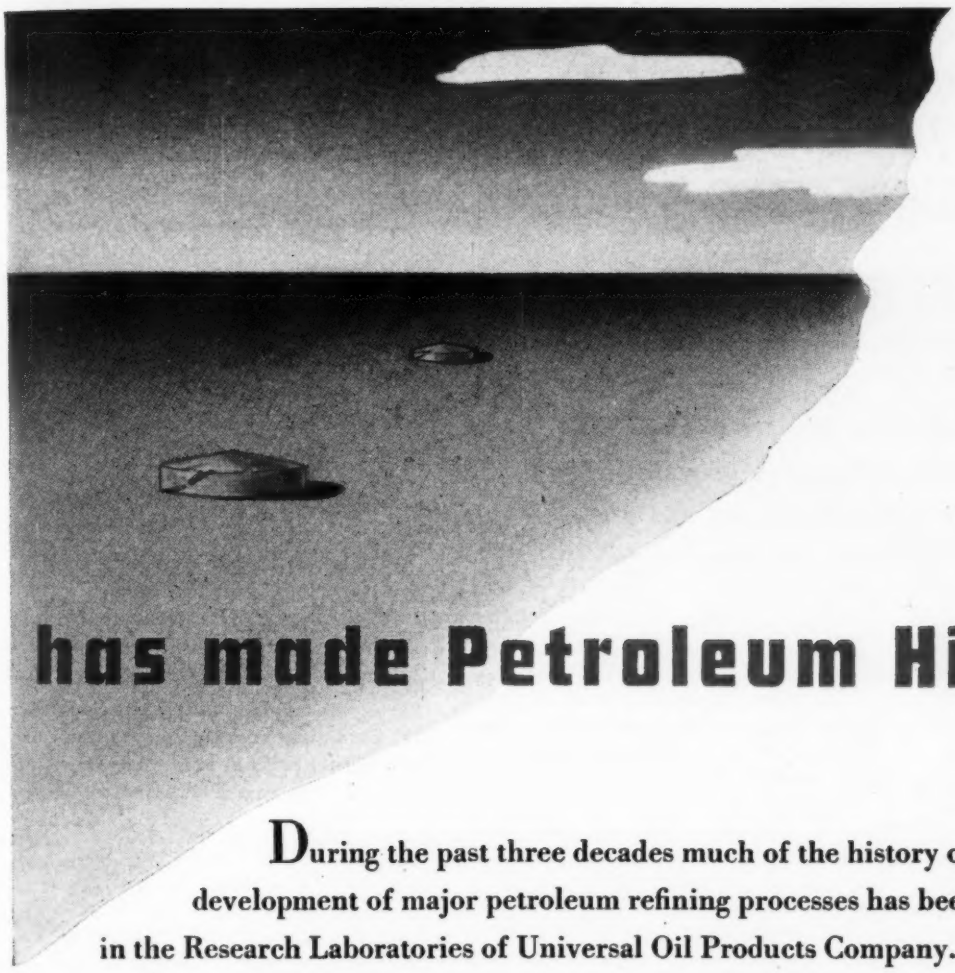

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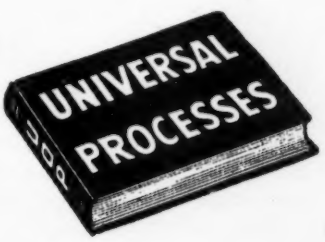


New Process Combines Advantages Of Fluid and Moving Catalytic Beds

In addition to the improved catalytic process described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued includes:

- **Ease of assembly, efficiency are features of shaft seal**
- **Safety valve closes quickly under surge of water in line**
- **New pipe wrench features adjustable jaws and arm**
- **Density difference operates low water alarm for boiler**

AN IMPROVED catalytic cracking process which is claimed to combine the advantages of fluid and moving bed processes without their disadvantages has been patented by a technologist at Union Oil Co. of California.

Granulated catalyst moves in a single continuous path, being carried from bottom to top by suspension in a flowing stream of gas; thence after separation from the suspending gas, flowing downward by gravity in a continuous solid moving bed through reaction and regeneration zones. The process is said to be adaptable to many forms of hydrocarbon conversion, including cracking, polymerization, reforming. In additional modified forms, it may be used in dehydrogenation, desulfurization, or hydrogenation.

No complicated mechanical conveyor systems and no balancing of catalyst flow in reactor against flow in regenerator are necessary, it is stated.

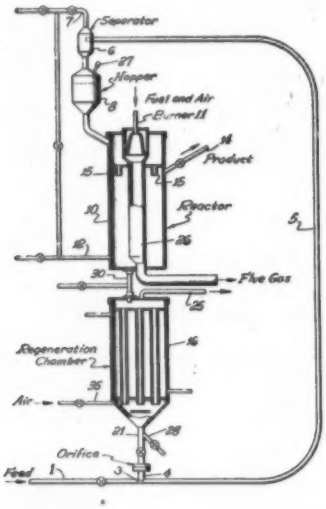


Fig. 1—Improved cracking process (U. S. 2,408,600). Preheated feed carries regenerated catalyst through line 5 to separator 6, where catalyst flows downward by gravity through reactor 10, while feed re-enters system at 12 and passes countercurrent to catalyst

Feed stock is used as the means for transporting catalyst from the bottom to the top of the unit. By the use of a separator and by-pass piping, the feed then enters the reaction chamber countercurrent to the catalyst flow.

A diagram of the process is shown in Fig. 1. Vaporized and preheated feed enters at 1, picking up catalyst at 3, carrying it in suspension through line 5 to separator 6. Here the gas passes out through line 7, and the catalyst goes from hopper 8 in a solid, moving stream into reactor 10. Fuel gas, burning in combustion chamber 26, heats the reactants by indirect exchange.

The hydrocarbon vapors enter the reactor at 12, moving counter-currently to catalyst flow. Products leave through line 14, downcomer tubes 15 providing a catalyst-disengaging space.

Spent catalyst passes down through line 30 into regenerator 16 where it is regenerated by air entering through line 35, and is cooled by indirect heat exchange. Regeneration flue gases leave through line 25, and regenerated catalyst passes out through line 21. It is then either taken into line 4 to repeat the cycle, or it is withdrawn at 28 and added to hopper 8 through line 27.

U. S. 2,408,600, issued Oct. 1, 1946, to Clyde H. O. Berg, assignor to Union Oil Co. of California.

Ease of Assembly, Efficiency Are Features of Shaft Seal

CONSISTING of a pair of collars, a packing ring, a spring, and an anchoring pin, a recently invented seal is said to prevent leakage of fluids between a shaft and its bushing; for example, a pump drive shaft.

In Fig. 2, shaft 10 is shown mounted in bushing 11. Seal is actually provided by packing ring 13, preferably synthetic rubber, contained in collar 12. Groove 18 in collar 12 is slightly smaller than the thickness of the ring so that when in place, the ring is flattened against the shaft. Immediately adjacent to collar 12 is placed a drive collar 15 (shown in detail Fig. 3), which is held in place by means of pin 27 fitting in a slot in the shaft. Collar 12 supports a spring 14, by means of which a constant force is applied against the collar 12, thus sealing the shaft.

U. S. 2,411,509, issued Nov. 26, 1946, to Peter Endebak, assignor to Tuthill Pump Co., Chicago, Ill.

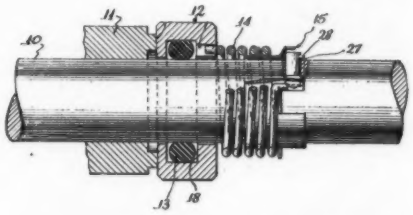


Fig. 2 — Shaft seal (U. S. 2,411,509). Spring 14 exerts pressure against collar 12 containing packing ring 13, thus preventing leakage of fluids between shaft 10 and bushing 11

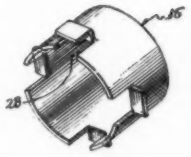


Fig. 3 — Details of construction of slip ring collar 15 which supports the spring 14 shown in Fig. 2

Safety Valve Closes Quickly Under Surge of Water in Line

DAMAGE to steam-operated equipment is preventable with a new safety valve which will close a steam line in the event of a surge of water.

Under normal conditions, the valve will permit the flow of steam. It is provided with an indicator which shows the position of the valve and therefore the amount of steam passing through the line.

The device is shown in Fig. 4. The

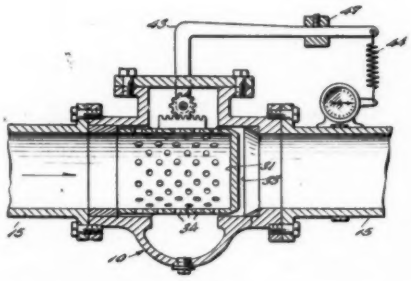
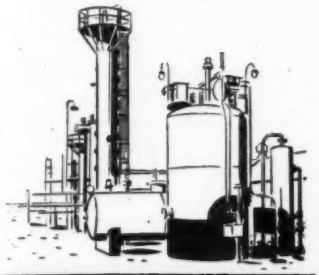


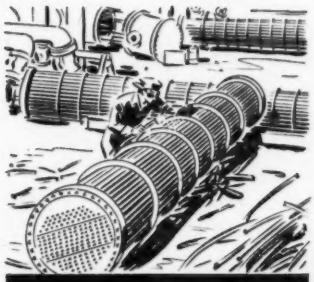
Fig. 4—Steam line safety device (U. S. 2,410,984). Steam flow is from left to right through openings 34 in valve 31. A sudden surge of water forces valve 31 to right into valve seat 33, preventing further flow

THESE 8 ADVANTAGES OF PETRECO DESALTING ARE REFINERY MONEY SAVERS



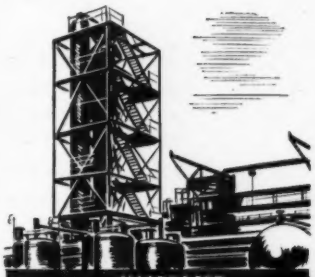
1 HIGH PERCENTAGE SALT REMOVAL

Petreco Desalting usually insures a salt removal of 90% or better, with 98% not uncommon.



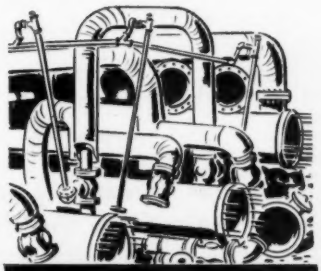
2 CORROSION PREVENTION

Petreco Desalting reduces corrosion by curtailing the evolution of HCl.



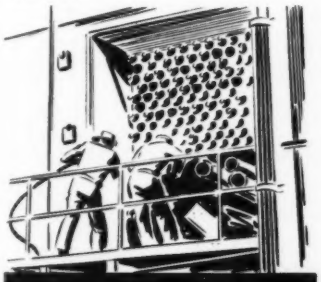
3 INCREASED CRACKING EFFICIENCY

A refinery comparison of two cracking stills shows a ½ cent per barrel gain for the still handling desalted crude—after desalting costs were met.



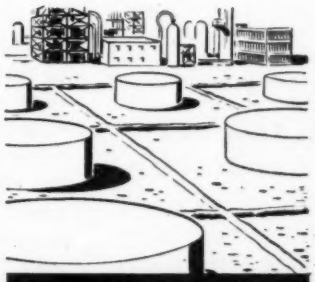
4 LESS "DOWN TIME"

"Down time" is frequently reduced as much as 50 to 90% wherever Petreco Desalters are installed.



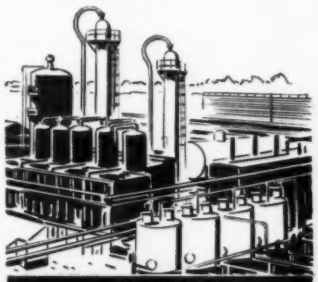
5 ELIMINATION OF PLUGGING

A Petreco Desalter virtually always eliminates salt plugging.



6 TANK BOTTOMS DISPOSAL

Many refiners materially increase tank storage space by adding tank bottoms to the crude being desalted.



7 INCREASED REFINING CAPACITY

Increases in refining capacity varying from ten to several hundred per cent are frequently credited to Petreco Desalters.

8 PETRECO SERVICE

Petreco engineers supervise every desalter installation, and inspect equipment periodically—they are constantly "on call."

In many cases, the savings accruing from one or two of these advantages are more than enough to defray the nominal cost of Petreco Desalting.

For complete information, and a tentative plan for Petreco economies in your operations, have a Petreco engineer call on you. Economical process improvements have frequently started with a Petreco conference. There is no charge for this service.

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530 West Sixth Street, Los Angeles 14, California

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PETRECO

DESALTING ★ ELECTRICAL PROCESS ★ DEHYDRATING

valve body 10 is mounted in the steam line 15. Flow is from left to right. Spring 44 and, if desired, weight 47, on crank arm 43, operating through a pinion and rack, serve to keep valve 31 open. Steam will easily flow through the openings in the side walls of the valve. However, a surge of water will exert greater force than the spring and weight, and will push the valve into seat 33, preventing further passage of water.

U. S. 2,410,984, issued Nov. 12, 1946, to Timothy E. Lawless, Marcellus Falls, N. Y.

New Pipe Wrench Features Adjustable Jaws and Arm

A PIPE WRENCH, which it is claimed will not deform the pipe to which it is applied in the same manner as a straight jaw type of pipe wrench, has recently been patented.

The improvement in design is in the adjustable jaws and adjustable arm, it is said. The wrench is shown in Fig. 5. The jaws are shaped so as to fit around the surface of the pipe. In addition, the design permits easy access for the operator in cramped or narrow quarters, and allows quick and easy release.

U. S. 2,407,990, issued Sept. 24, 1946, to Benjamin L. Lurie, Chicago, Ill.

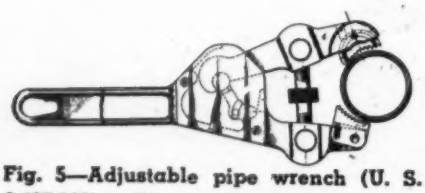


Fig. 5—Adjustable pipe wrench (U. S. 2,407,990). Circular form of jaws permits maximum number of teeth to engage pipe

Density Difference Operates Low Water Alarm for Boiler

THE DIFFERENCE in density of steam and water is the principle upon which the design of a newly invented low water alarm for steam boilers is based. It is claimed that the device can be adapted for use in any tank or vessel in which two media of varying densities are contained.

Shown in Fig. 6, the alarm device is installed in the wall of the water column 11 of a boiler, at a point in alignment with the low water level. Regardless of water level, the steam pressure at all times operates through port 33 against the blades of the small turbine 24, thus rotating shaft 18, clappers 25, and propeller 23. Shaft 18 can slide from left to right in its bearings.

As long as the propeller is immersed in water, its thrust maintains the shaft in a position so that the clappers revolve clear of bell 35. However, when the water

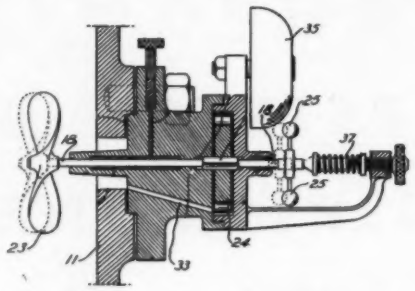


Fig. 6—Low water boiler alarm (U. S. 2,411,457). Propeller thrust against water keeps clappers free of alarm bell. When water level falls below the propeller, its thrust becomes ineffective, and spring forces clappers aganist bell

level drops low enough so that the propeller rotates in steam, its thrust becomes ineffective. Then the force of spring 37 moves the shaft to the left and the clappers begin striking the bell.

Instead of steam for driving the turbine, a small electric motor can be used. In this case, variations in current load can be utilized to actuate the alarm or some control mechanism, it is stated.

U. S. 2,411,457, issued Nov. 19, 1946, to Frank M. Patterson, Pitman, N. J.

Heat Exchanger in Fluid Unit Improves Light Oil Processing

A HEAT EXCHANGER incorporated as a part of a fluid catalytic cracking system improves its efficiency and is said to overcome difficulties in processing of relatively light oils in reforming or of normally gaseous hydrocarbons in dehydrogenation.

In one form of the invention, the

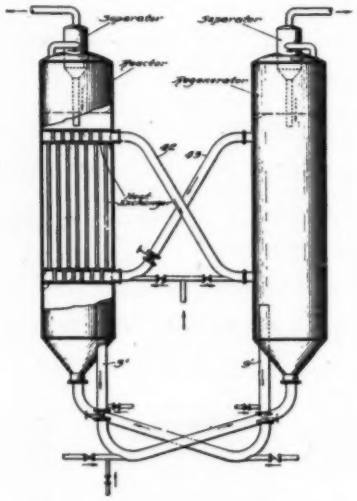


Fig. 7—Heat exchanger in fluid catalytic cracking unit (U. S. 2,412,025). transfers maximum amount of heat from exothermic regeneration reaction to endothermic reaction in reactor. Flow is indicated by arrows

exchanger is placed inside the reactor, as shown in the simplified drawing in Fig. 7. Hot catalyst flows from the regenerator through duct 43 to the exchanger, returning through duct 42. In another design covered by the same patent (not shown), the heat exchanger is placed outside both vessels. In that design, hot catalyst flow from the regenerator through the exchanger to pipe 3, while a reactant stream flows from the top section of the reactor through the exchanger to pipe 9.

In this arrangement, it is claimed that the greatest quantity of heat from the regeneration is supplied to the endothermic reaction in the reactor. An alternative method, that of preheating the charge, would result in excessive and undesirable thermal conversion.

U. S. 2,412,025, issued Dec. 3, 1946, to Gordon B. Zimmerman, assignor to Universal Oil Products Co., Chicago.

Device Collects Gas Samples From Inaccessible Locations

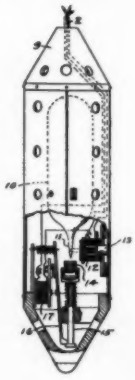


Fig. 8 — Remote controlled gas sampler (U. S. 2,411,157). Solenoid 12 breaks sealed tip on sample bottle 10, and solenoid 17 operates closing mechanism after sample has been taken. Device is suspended on three-wire cable 2 wound on a hand reel

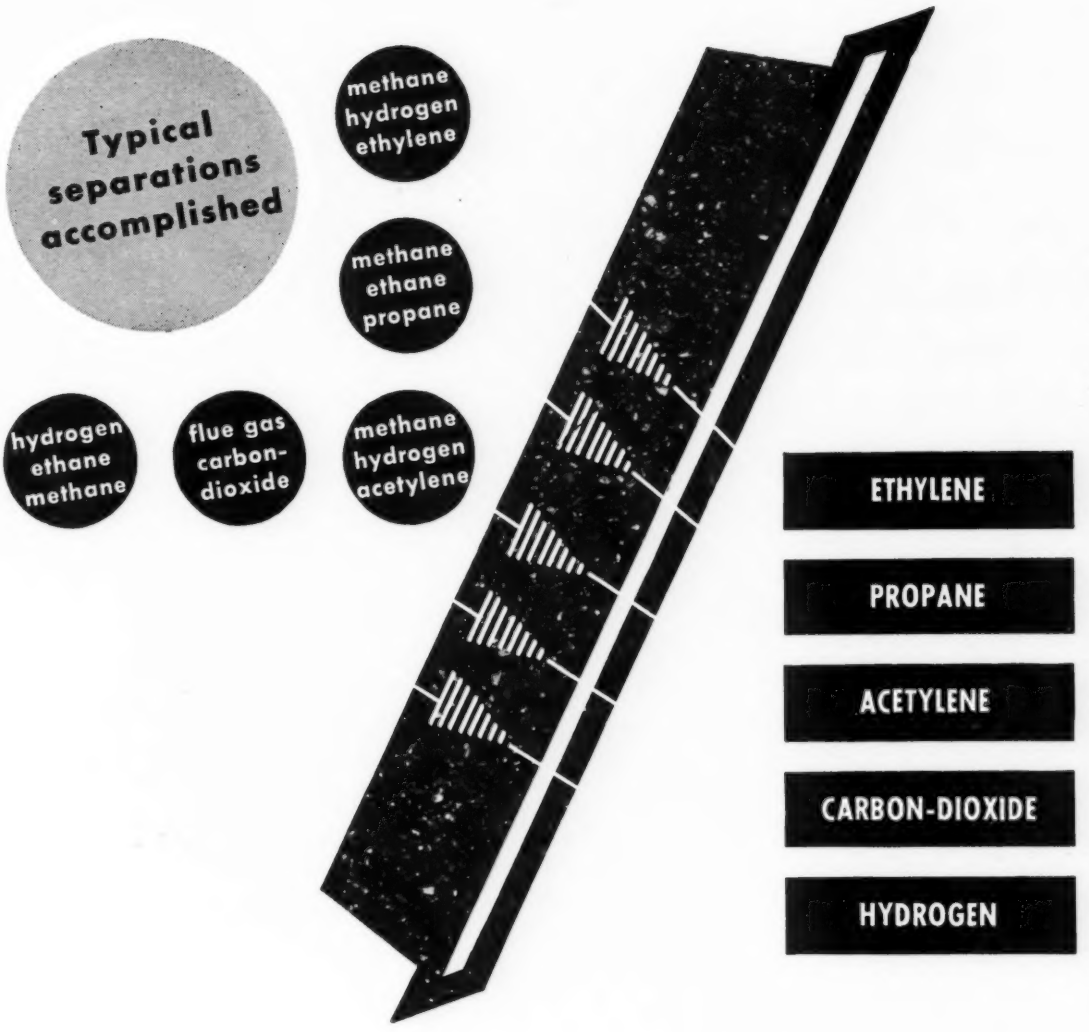
REMOTE CONTROL by electricity operates a gas sampler for collecting samples in difficultly accessible locations. Designed primarily for use in obtaining samples of gas in coal mines, deep bore holes in the earth, ship holds, and the like, the device should find applications in tanks and processing vessels in the refining industry.

Consisting of a metal shell, the sampler is shown in Fig. 8. Sample bottle 10, an evacuated glass container, is housed in the outer shell 9, which is suspended on 3-wire cable 2. Controlled by switches, the 3-wire cable actuates two solenoids in the sampler. One solenoid 12 moves plunger 13 to break sealed tip 11. After the sample has been taken, the second solenoid 17 trips latch 16, releasing plunger 15, and a spring forces sealing cup 14 tightly against the previously broken tip 11.

The 3-wire cable is wound on a reel and serves as a suspension means for the sampler.

U. S. 2,411,157, issued Nov. 19, 1946, to William J. Fene and George L. Freas, assignors to the Government of the United States as represented by the Secretary of the Interior.

hypersorption



Activated charcoal, in a continuously circulated stream, separates gases of 99+ percent purity from complex gaseous mixtures in this new selective adsorption process — a development of the Union Oil Company of California.

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hypersorption

This Hypersorption column is shown under construction at our Carteret, New Jersey works. It will be erected at the Midland, Michigan plant of the Dow Chemical Company. • The photographic view is from the top down, showing (a) the cooling section, (b) the charge and product manifolds and (c) the heating section. The heat is supplied by a Dowtherm vapor heating system. • A complete technical description of the Hypersorption process is presented in a reprint from the Trans. A.I.Ch.E. (August 1946) titled "Hypersorption Process for Separation of Light Gases" by Clyde Berg, Research Department, Union Oil Company of California.

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Fischer-Tropsch Process (U. S. Model) Is Means of Supplying Low Cost Oxygen

New Method of Manufacturing Oxygen for Use in Synthesizing Liquid Fuels from Natural Gas Can Also be Applied to Make Conversion of Coal Economically Practicable, It Is Claimed

Oxygen can now be separated economically from air by new developments which treat the air as a binary mixture of nitrogen and oxygen, removing the latter by fractionation. The fractionating process, which has been used as the basis of design for one 2000 ton/day plant now being erected, and the major equipment requirements are described.

This article is based chiefly on a paper "Equipment for Low Cost Oxygen Production," by Martin J. Conway, steel industry consultant, Stacey-Dresser Engineering, presented before the Petroleum Meeting of the American Society of Mechanical Engineers at Tulsa, Oct. 7, 1946, and on first-hand information obtained later by PETROLEUM PROCESSING from Mr. Conway.

LOW cost, high purity oxygen, soon to be manufactured — and utilized — in the U. S.-improved Fischer-Tropsch process for making synthetic fuels from natural gas, may also be used later in converting coal into liquid products.

It is claimed that oxygen can be produced in connection with the operation of a Fischer-Tropsch plant at a cost of 5c/1000 cu. ft., about 40% of the cost by present established commercial methods. The oxygen-utilization development has greatly reduced the cost of making synthetic liquid products from natural gas by Fischer-Tropsch, and will go far towards making economically practicable the synthesizing of coal, it is stated.

Proved out in pilot plant operations at Olean, N. Y., commercial units for the production of oxygen are being built along with two Fischer-Tropsch plants in the southwest. Completion of these two units will increase the national consumption of oxygen by more than 31 billion cu. ft. annually, in comparison with the current total consumption of 19.5 billion cu. ft./yr.

A 2000 ton/day unit, said to be the largest in the country, is now under construction as part of the synthetic fuel plant of Carthage Hydrocol, Inc at Brownsville, Texas.

It will provide 48 million cu. ft. of 95% purity oxygen daily. The cost estimate of 5c/1000 cu. ft. includes amortization over a period of 15 years, maintenance at 2% of the capital investment and operating labor, direct and indirect, at $2.00/hr.

Power (mounting to less than 14 KW/1000 cu. ft. of oxygen) and water costs are excluded from the cost of manufacture as they are both by-products of the Hydrocol process and are automatically covered in the price paid for natural gas.

A similar capacity unit is to be built in connection with another gasoline-from-natural gas plant, that planned by Stanolind Oil & Gas Co. in the Hugoton field of Southwestern Kansas.

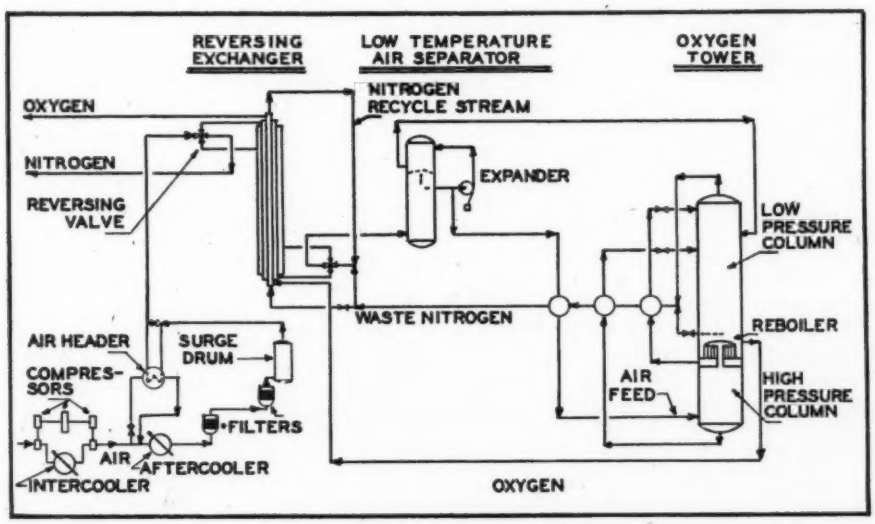

Fig. 1—Simplified flow diagram of low cost oxygen manufacturing process by liquefaction and fractionation of air

Oxygen Manufacture

The fractionation process treats air as a binary mixture of nitrogen and oxygen, bleeding off accumulated noncondensibles such as argon, etc. It may, however, be designed to separate argon also by means of additional fractionation equipment. Pilot plant work in a 4000 cu. ft./hr. unit was first done at Olean, N. Y. with the installation later being transferred to the laboratories of Hydrocarbon Research, Inc. at Trenton, N. J. It is this unit which is described in terms of design for the Brownsville unit.

The operations involved consist essentially of compression, heat exchange, refrigeration, and fractionation. The flow through the process is shown in Fig. 1.

Air Is Compressed to 85 psig

Atmospheric air is filtered and then compressed to about 85 psig in two stages. The compressor is designed to handle 10% excess air to allow for moisture in the air feed and losses in the exchangers on reversal. The air is compressed to 30 psig in the first stage and cooled to 100° F. It is then compressed to 85 psig in the second stage and again cooled, from 300 to 100° F.

The residual oil and moisture are

filtered out and the oil vapors are absorbed in a filter containing activated carbon pellets. The compressed air then flows to a multi-annulus reversing exchanger where it is cooled directly against waste nitrogen and oxygen.

As it is cooled, moisture and carbon dioxide precipitate out and tend to foul the air passage. Before this can happen, however, the flows through the exchanger are reversed. The air is diverted to the annulus which had carried waste nitrogen in the previous half-cycle. On the other hand, the waste nitrogen now passes through the annulus which contains the ice and carbon dioxide snow.

By this reversal, the ice and carbon dioxide snow are re-evaporated into the nitrogen stream and discharged into the atmosphere. The full cycle occurs every three minutes. Thus, the exchanger not only cools but also purifies the air, and does so without the necessity for chemicals. The oxygen stream passes through the innermost annulus without interruption and is therefore not contaminated.

After the air leaves the exchanger, it is discharged into a surge drum at approximately −250° F., where the main portion, or about 70%, passes directly from the surge drum to be further cooled by exchange against the waste nitrogen. The remaining 30% is used to provide refrigeration.

Fractionation

The cooled high pressure air enters the lower section of the fractionating tower below the bottom tray. This section, called the high pressure section, contains 20 trays and separates the air into an overhead liquid nitrogen product of low oxygen content and a bottom liquid of about 35% oxygen content.

The nitrogen overhead liquid is subcooled by exchange against the waste nitrogen and supplies reflux to the upper section of the fractionator, where it is introduced at the top tray. This section of the column, containing 40 trays, operates at about 10 psig.

The enriched oxygen product from the bottom of the high pressure section is similarly cooled by exchange against waste nitrogen and then introduced into the low pressure column as intermediate reflux. The expanded air is also introduced into the low pressure column at an intermediate point.

The low pressure section fractionates the feeds into a waste nitrogen stream, removed as an overhead vapor, and an oxygen product, withdrawn from below the bottom tray, also as a vapor. The reboiler duty is supplied by the condensation of the overhead vapors in the high pressure section, part of which are withdrawn for reflux to the low pressure section, the balance passing down through the high pressure section as internal reflux.

As previously described, the waste nitrogen passes through the three stationary-flow exchangers before entering the reversing exchanger. Its temperature entering the reversing exchanger is controlled by by-passing a small percentage of the nitrogen stream through the center tubes of the bank in the reversing exchanger, and recycling this stream back to the cold end of the reversing exchanger where it is mixed with the main nitrogen stream.

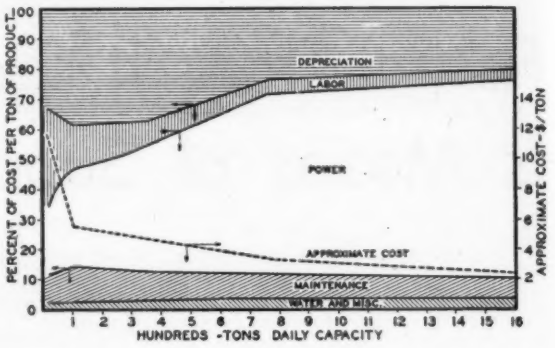

Fig. 2—Chart showing relative manufacturing costs of 90-95% purity oxygen. Broken line indicates approximate cost of product in dollars/ton. Large percentage of total cost of power increases steadily as plant capacity increases. This factor is excluded in estimates for Brownsville plant because power is by-product of synthesis process

Recycle Controls CO_2 Fouling

This recycle, called an unbalance stream, allows the temperature to be controlled at the inlet end at approximately −258° F., thus insuring complete removal of carbon dioxide. Without this temperature control, only part of the carbon dioxide would be re-evaporated, thereby eventually causing a shutdown due to excessive pressure drop. The waste nitrogen, after leaving the reversing exchanger, is vented to the atmosphere.

The oxygen product passes from the low pressure section of the fractionator directly to the inner annulus of the reversing exchanger where its refrigeration is recovered. It then enters the service lines and may be subsequently compressed to suit service conditions.

In the design of these large oxygen units it was necessary to draw generously from known petroleum industry equipment practice. A review of the history of design of oxygen plants indicated that at the time engineering decisions were being made for these large units, the largest plant in operation in the United States had a capacity of about 40 tons/day. This was a factor of 1 to 50 when compared to the size of the plant now under construction.

Uses Centrifugal Compressors

In order to produce 48 million cu. ft./day of oxygen, it is necessary to compress approximately 250 million cu. ft./day of air (174,000 cfm) to a pressure of 75-85 psig. The cost of reciprocating machines for this purpose is prohibitive. It was found that loads of over 800 to 900 cfm of air were the upper limits for reciprocating compressors.

Centrifugal compressors are used, having radial intake and axial discharge; the true axial compressor is not capable of producing the quantities desired at the necessary pressure. There are two units in parallel, each unit being driven by a 20,000 hp steam turbine deriving steam as a by-product from the exothermic Fischer-Tropsch reaction in the main plant.

Designed to operate at about −310° F., the fractionating columns must be fabricated of such special materials as copper, aluminum, stainless steel, and others. Two fractionators in parallel are actually used to avoid excessive heights and keep the unit compact as a means for minimizing heat leaks into the system.

Complete insulation of all major items of equipment is necessary because of the extremely low temperature levels for operation. These temperatures, in the neighborhood of −300° F., require metals for fabrication having a guaranteed Charpy impact value in excess of 15 ft.-lbs. when tested at operating temperatures. Such metals are costly—about 5 to 1 when compared to ASME Code vessels for normal medium pressure service.

Power Cost Important in Large Plants

This equipment cost factor is important in small oxygen manufacturing plants; but in larger operations, the power cost is the most important item, especially where power exceeds 5 mils/KW-hr. in cost.

An estimate of the proportional effect of certain major cost items on the cost of manufactured oxygen is indicated in Fig. 2. It can be readily seen that 5 mil power accounts for about 65% of the cost. Reductions in power cost would therefore produce the largest reduction proportionately in manufacturing cost. This graph is not intended to interpret correctly the exact cost of oxygen at all points on the scale, but it does show trends proportionate to the daily output as the plants increase in size. The basis on which it is drawn is: 15 year depreciation; labor, including all indirect labor costs, at $2.00/hr.; power at 5 mils/KW-hr.; and maintenance at 2% of the capital investment.

The advent of cheap oxygen opens up possibilities for its large scale use in six fields, it is stated: partial oxidation of hydrocarbon gases, gasification of coal, heavy chemical industries, iron and steel manufacture, nonferrous metal industry, and mining.

For trouble-free flow control ..... install POWELL Valves

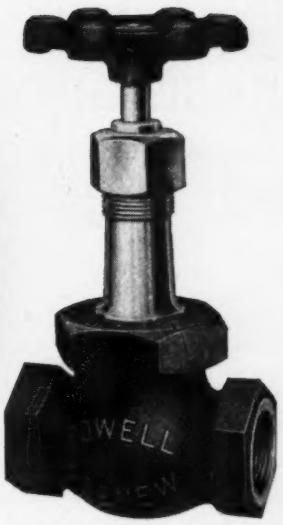

Fig. 190—150-pound Iron Body Bronze Mounted "Irenew" Globe Valve. Has screwed ends, union bonnet and regrindable, renewable wear-resisting "Powellium" nickel-bronze seat and disc.

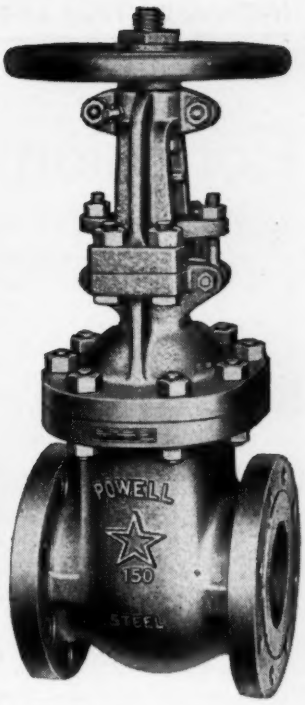

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc.

There are at least two notable reasons why Powell Valves minimize flow control troubles. One is that every valve in the Powell Line has been scientifically designed to operate under certain specific flow control conditions—pressure, temperature and/or media. The other is that there's a Powell Valve for *every* operating condition, or set of conditions, known today.

That's why so many plants, representing every phase of modern industry, are now standardizing on Powell Valves.

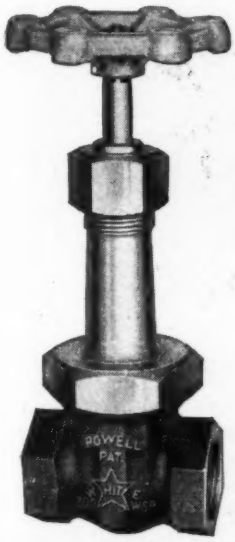

Fig. 375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel bronze disc.

Fig. 1561—Class 150-pound Cast Steel Swing Check Valve with flanged ends and bolted cap. Disc, when wide open, permits full unobstructed flow through the valve body.

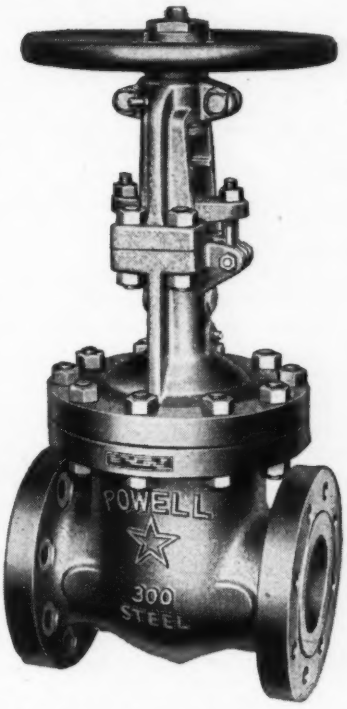

Fig. 3003—Class 300-pound Cast Steel Gate Valve with bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

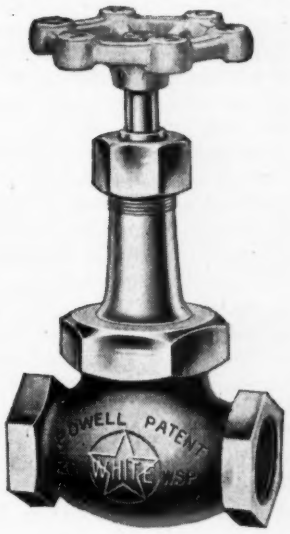

Fig. 1708—200-pound Bronze Globe Valve. Has screwed ends, union bonnet, renewable, specially heat-treated stainless steel seat and regrindable, renewable, wear-resisting "Powellium" nickel-bronze, plug type disc.

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Corrosion Resistance of 27% Chrome Alloy Recorded High in Plant Service Tests

SUGGESTIONS for the more effective commercial use of 27% chromium-iron alloy by petroleum refiners are given in a report based on 30 metallurgical studies made by several oil companies and the Babcock & Wilcox Tube Co., for the Office of Rubber Reserve. The report was made especially for the plants manufacturing butadiene during war. However, data in it may be found applicable in some of the other high temperature catalytic reactions in which refiners are now more and more engaging.

The relative chemical inertness of the 27% chrome alloy under alternate oxidizing and reducing conditions was a valuable property in its use in the catalytic dehyrogenation of normal butane in making butadiene, the report states.

However, because of certain loss of ductility under high temperature conditions, such as are encountered in many refining operations, various recommendations concerning fabrication, welding repairs, maintenance and operating practice were found necessary. These recommendations and the data on which they are based are given in the report written for the Office of Rubber Reserve by H. D. Newell, chief metallurgist of Babcock & Wilcox Tube Co.

Loss of ductility or embrittlement, due to sigma phase precipitation or "885° F. embrittlement" (or both), would appear to be the one most deleterious factor curtailing the useful life of this alloy in dehydrogenation plants, according to Mr. Newell. Sigma phase is a brittle intermetallic chromium-iron compound which forms in alloys containing more than about 25% chromium on long heating between 950 and 1250° F. Its precipitation causes increased hardness and drastic loss of ductile properties, he said. A sample of a tube fractured by embrittlement is shown in Fig. 1.

"An understanding of the characteristics of this alloy warrant several suggestions in the interest of securing satisfactory service and minimizing maintenance and breakage," Mr. Newell continued.

Recommendations for Welding

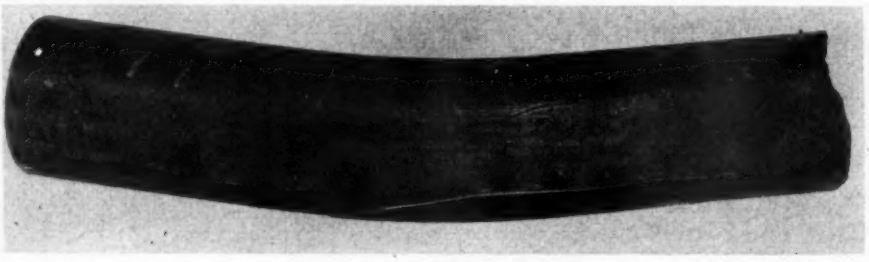
For welding, he suggested use of a nickel-bearing austenitic or partially austenitic welding electrode, preheating to 400 to 800° F. before welding, stress relieving at 1300° F. minimum immediately afterwards, followed by rapid cooling. Preheating has been dispensed with on thin gage metal as well as in certain very simple forms of butt-joints without encountering underbead cracking. To avoid undue difficulties, however, it is usually desirable to preheat before welding.

"Sharp notches and re-entrant angles in design or repair should be avoided, as well as folds, nicks, scratches, or stamping of numbers," Mr. Newell said. "Shock stresses (pounding, hammering, vibration) should be avoided, but if required, should be performed when the metal is at 550° F. or higher.

"In assembly, the use of copper gaskets on certain types of flanges and hand hole fitting seats has helped maintain tight, leak-proof joints. Graphite, applied to threads and contact areas of bolted fittings, will reduce galling and sticking.

"In order to avoid 885° F. embrittlement, cooling after service should be relatively rapid through the 1100 to 700° F. range. Below 700° F. the cooling should be more moderate to avoid undue mechanical (thermal) stresses in structures of complicated design. Sigma phase may be removed by heating for not less than one hour at a minimum temperature of 1500° F., and then quickly cooling through the range 1100 to 700° F., to avoid the 885° F. embrittlement.

"Catalyst regeneration procedures must be controlled at all times to prevent overheating. An excessive temperature would be one that is high enough for carburi-



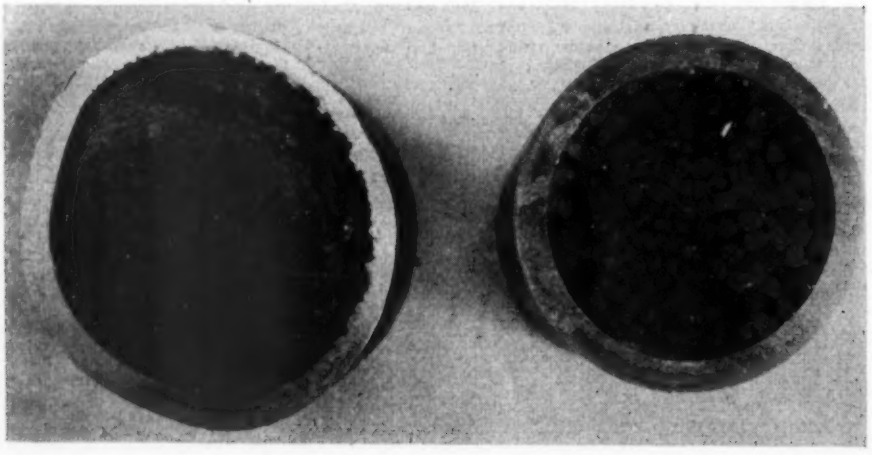


Fig. 1 (Above)—Brittle fracture in 27% Cr-Fe alloy catalyst tube removed from dehydrogenation service at Phillips Petroleum Co., Plains plant, Borger, Texas. Fig. 2 (Left)—27% Cr-Fe alloy catalyst tubes after service in dehydrogenation unit, also at Phillips' Plains plant. The tube at left has been badly carburized and bulged from excessive overheating. Both are plugged with a fused mass of catalyst and coke

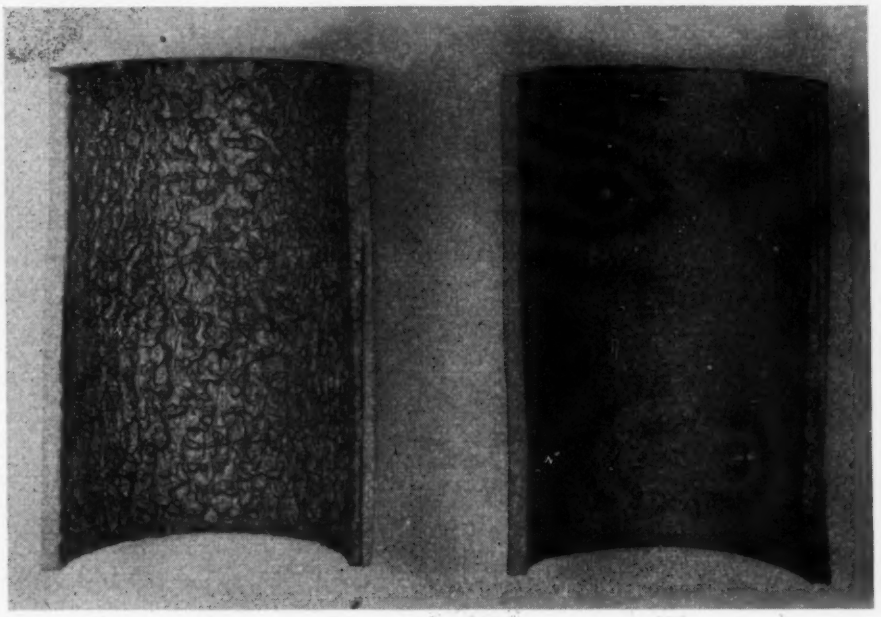


Fig. 3—Bulged catalyst tube of 27% Cr-Fe alloy shown at left in Fig. 2 after splitting. Portion at right has been cleaned by sandblasting

zation of the metal, which probably means temperatures in excess of about 1700° F. and also means loss of chemical resistance of the metal. Ordinarily the maximum temperature reached during normal operations of dehydrogenation should not exceed about 1350° F., except during heat treatment for sigma phase removal. Samples of failure from overheating may be seen in Figs. 2 and 3.

"Metal dust and ordinary steel articles which are inadvertently left in equipment may lead to excessive carbon formation and plugging of catalyst tubes. High conversion temperatures may stimulate carbon formation, and low regeneration gas pressure may result in incomplete reactivation, leaving tubes in a plugged condition. Volume increases from the coke formed causes excessive stressing of the tube metal with bulging or fracture. Conversely, regeneration gas high in oxygen content may cause excessive temperature and may actually melt the tube wall and catalyst support grid."

The research program on 27% chrome alloy, under Mr. Newell's supervision, included laboratory tests by Babcock & Wilcox, and pilot plant and plant exposure tests by the cooperating oil companies. These were Phillips Petroleum Co., Universal Oil Products Co., Shell Oil Co., Standard Oil Co. of California, and Sun Oil Co.

Relative Behavior Studied

The investigations studied the relative behavior and evaluated the suitability of the 27% chromium-iron alloy under the actual conditions involved in the catalytic dehydrogenation process. Specifically, these conditions are:

1. Temperatures of 900 to 1500° F.
2. Oxidizing conditions due to catalyst regeneration.
3. Reducing conditions due to the action of the catalyst whereby free hydrogen, carbon, and unsaturated hydrocarbon compounds are formed.
4. The oxidizing and reducing conditions alternately existing in the same reaction chamber or catalyst tube.
5. The necessity that the reaction chamber be kept practically free of iron and iron oxide.

Pilot plant work has demonstrated that, under the conditions employed in dehydrogenation of n-butane, some ferrous alloys suitable for high temperature service are attacked and generate a dust with undesirable catalytic effects, said Mr. Newell. "This dust collects on the surface of the catalyst with the result that carbonaceous deposits are formed at an accelerated rate until finally the tube is plugged."

Several companies—Phillips, Universal Oil Products, and Shell—carried out extensive laboratory and pilot plant tests using tubes of various compositions, such

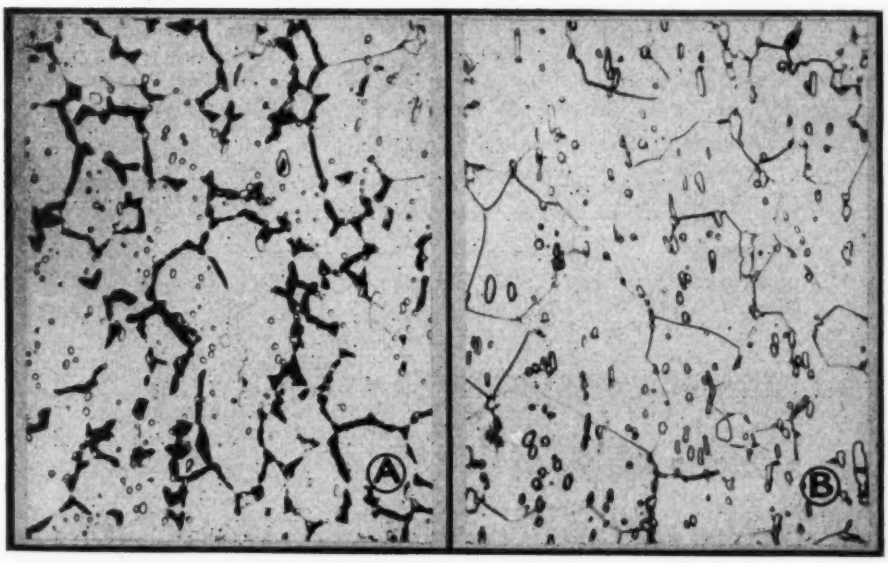


Fig. 4—Microphotographs of 27% chromium-iron alloy plate from service in catalyst vessels at Toledo Butadiene plant, Sun Oil Co. (A) shows a sample of plate as received after service (etch: aqua regia, magnification: X 1000). Note heavy sigma precipitate at grain boundaries. (B) shows same sample after heat treatment at 1550 F. for one hour (etch: aqua regia, magnification: X 1000). All sigma phase precipitate has been transformed to ferrite

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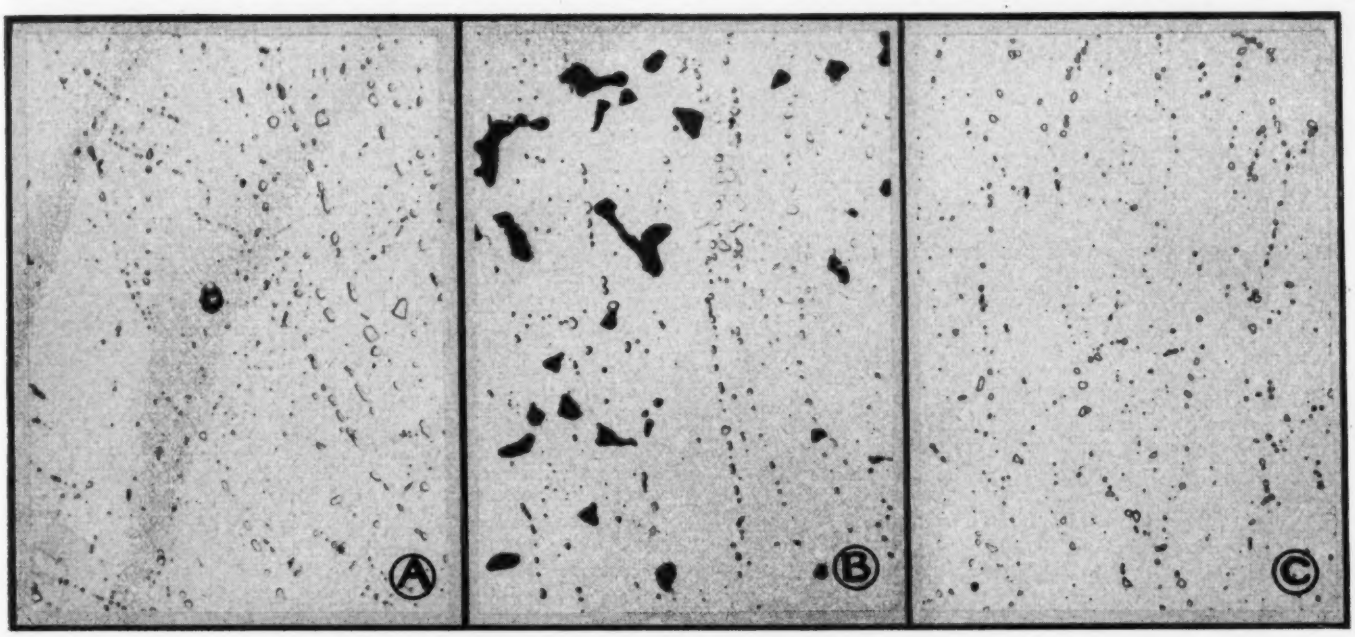


Fig. 5—Microphotographs of 25-20 Cr-Ni alloy catalyst tubes from First Step Dehydrogenation unit at Borger, Texas, plant of Phillips Petroleum Co. Tubes were in service 141 days. (A) shows carbide structure of the material before going in service (etch: aqua regia, magnification: X 2000). (B) shows carbide structure after service (etch: aqua regia, magnification: X 2000). Note dark patches indicating formation of a new constituent. (C) shows structure after 1 hour at 1750 F. (etch: aqua regia, magnification: X 1000). Sigma phase has completely dissolved in the austenite

as 18-8 Cr-Ni, 23-1 Cr-Cu, 27 Cr-nitrogen, 25-50 Cr-Ni, and 25-12 Cr-Ni. It was definitely established that the 27% chromium-nitrogen alloy best resisted dust formation and, in general, was well suited for other conditions of catalytic dehydrogenation, the report brings out.

Resistance Shown in Plant Tests

The superior resistance to corrosion in butadiene reactors of 27% chromium-iron, as compared with a great variety of Cr-Ni steels and nonferrous alloys, was demonstrated by plant exposure tests conducted by Standard Oil Co. of California and Sun Oil Co. The data shown in Table 1 indicate clearly that the oxidation rate was negligible and of the same order as that of the higher chromium-nickel steels.

Good service results were found on inspection of four samples of 27% chromium-iron reactor tubing which had been in use at the dehydrogenation plant of Universal Oil Products Co., at Heysham, England, for periods of time ranging from 21,000 to 22,640 hours.

In all samples ductility had vanished completely due to the presence, in varying quantity, of sigma phase. However, the tube material was restored to its original condition by quenching in water after one hour's heating at 1500° F. It therefore appears advisable, in cases where tubes have been removed from dehydrogenation reactor furnaces for whatever reason, to reanneal them before re-installation.

The heat treatment method for restoring ductility was also found practicable with several samples of the 27% alloy in sheets and plates removed from butadiene reactors following service at Sun Oil Co.'s Toledo plant. The plate sample represented the catalyst support plate, and the sheet samples were used along the inside face of the refractory lining to prevent gas infiltration to the wall of the steel vessel.

All samples were found to be quite brittle. Laboratory tests indicated that at least one of the plates had been heated in the 885° F. embrittlement range, whereas the two other specimens were in all probability heated at a somewhat higher temperature as evidenced by the presence of gross sigma phase precipitation. The chemical composition of all the samples averaged 27% alloy. However, it was noted that the sample with the highest chromium content exhibited the least amount of sigma precipitate, and was restored to proper ductility by heat treatment at 1100° F. A temperature of about 1550° F. was needed to remove hardness from the other two samples as shown in Fig. 4.

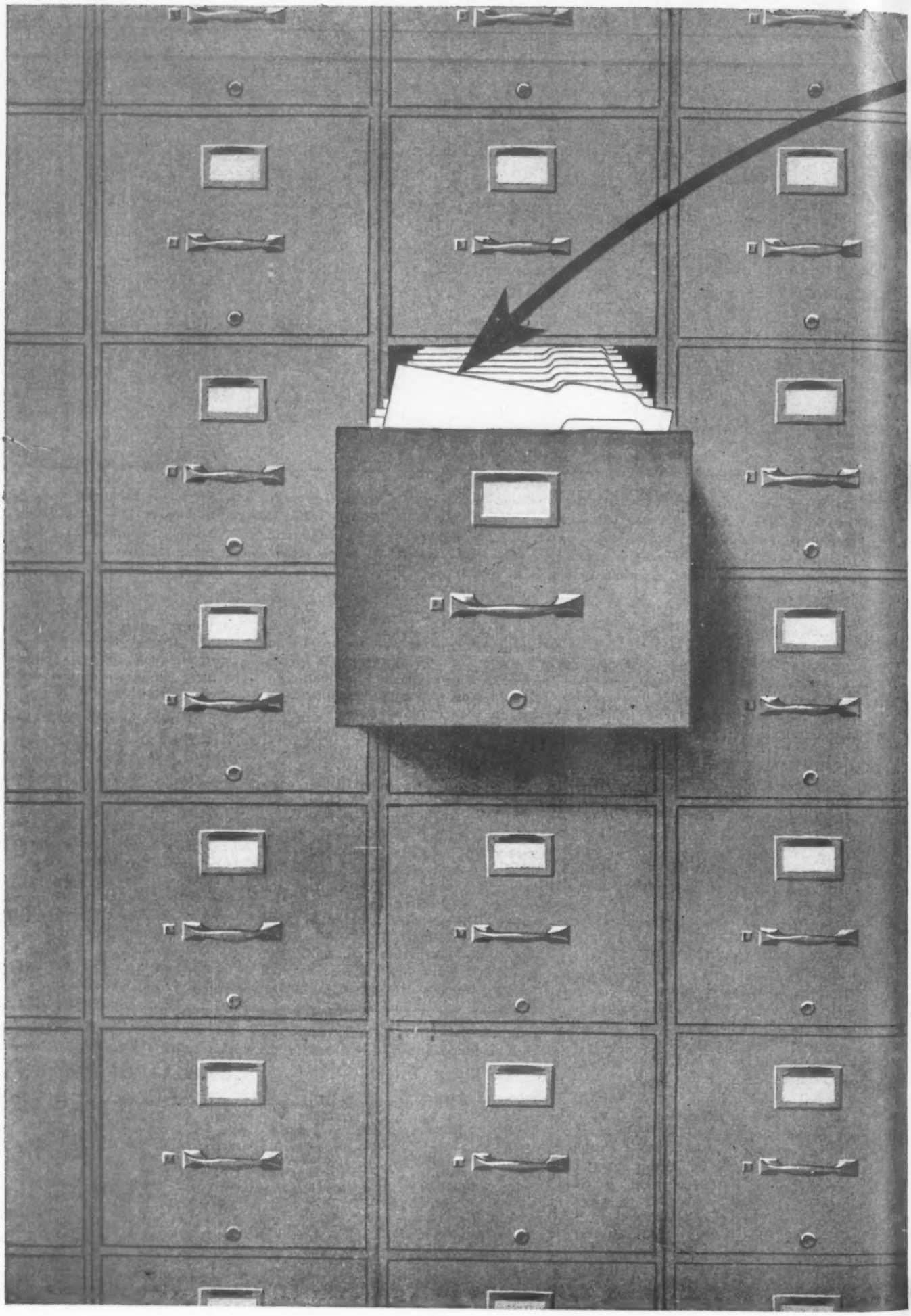
Butadiene Service Good

A number of other alloys were also given commercial service tests with varying results. One such investigation was of reactor tubing of 18-8-silicon material and of 25-20 Cr-Ni material. Both sections of tubing were subjected for 141 days to the cyclic oxidation-reduction environment in the first step dehydrogenation in the Phillips Petroleum Co. butadiene plant at Borger, Texas. Microphotographs of some of the samples are shown in Fig. 5.

No carburization of either alloy with subsequent breakdown of corrosion resistance occurred during the test, indicat-

TABLE 1—Oxidation Rate (In. per 1000 Hr.) of Various Alloys After Plant Exposure Tests in Butadiene Reactors at Standard Oil Co. of California and Sun Oil Co.

Material	Center of Reactor Below Catalyst Bed — Reactor Numbers — No. 2	No. 3	No. 4	No. 5	In Reactor Above Catalyst Bed No. 2
18-8 Cr-Ni	0.0005	0.0001	0.0001	0.0002	0.0001
18-8 Cr-Ni-Cb	0.0004	0.0001	0.0001	0.0001	0.0002
16-13-3 Cr-Ni-Mo	0.0002	0.0001	Nil	0.0002	0.0001
18-13-3 Cr-Ni-Mo	0.0001	Nil	Nil	Nil	0.0001
18-8-2 Cr-Ni-Si	0.0001	Nil	0.0001	0.0001	0.0001
Inconel	0.0037	0.0010	0.0017	0.0025	.....
25-12 Cr-Ni	Nil	Nil	Nil	Nil	0.0001
25-20 Cr-Ni	Nil	Nil	Nil	Nil	0.0001
27% Cr	Nil	Nil	Nil	Nil	0.0001
29-9 Cr-Ni	Nil	Nil	Nil	Nil	Nil
Copper	0.0016	0.0011	0.0012	0.0018	.....
Aluminum Bronze	0.0027	0.0053	0.0050	0.0045	0.0059
12% Cr-0.2% Al	0.0396	0.0225	0.0211	0.0298	.....



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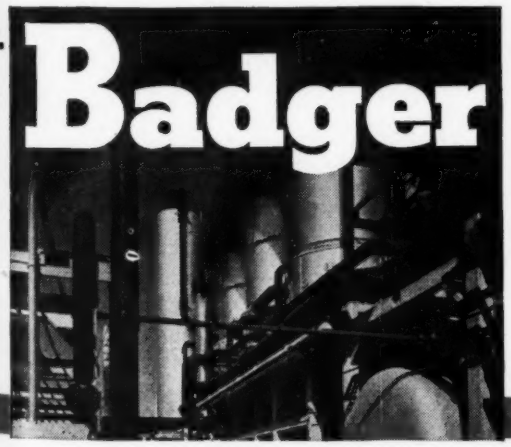

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Current Specifications for 27% Cr-Fe Alloy

	AISI Type 446*	AISI Type 446* (P-518-T Tubing)	ASTM A-268-44T† Tubing	ASTM A-176-44† Grade 6 (Plate, Sheet and Strip)	Maker A(1) Tubing	Maker B(1) Tubing
Carbon	0.35% max.	0.20% max.	0.20% max.	0.35% max.	0.15% max.	0.20% max.
Manganese	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.50 max.
Sulfur	0.040 max.	0.04 max.	0.030 max.	0.040 max.	0.030 max.	0.025 max.
Phosphorus	0.040 max.	0.04 max.	0.030 max.	0.040 max.	0.030 max.	0.025 max.
Silicon	1.00 max.	0.75 max.	0.75 max.	1.00 max.	0.75 max.	0.75 max.
Chromium	23.00/27.00	23.00/30.00	23.00/30.00	23.00/27.00	25.00/28.00	26.00/30.00
Nickel	.....	.....	0.50 max.	0.60 max.	.....	1.00 max.
Nitrogen	.....	.....	0.10/0.25	.....	0.10 min.	0.12/0.25

* Steel Products Manual, American Iron & Steel Institute.

† ASTM Standards, 1944 revision.

(1) Specification limits by two leading manufacturers of seamless tubing, indicating that the alloy is usually furnished to more restricted composition than the AISI range.

ing that service temperatures probably did not exceed about 1300° F. during the reducing portion of the operating cycle. Neither did any embrittlement occur in either material, and the engineers concluded that both alloys warrant consideration as materials for tubular catalyst elements.

Higher chromium-content alloys have higher chemical inertness, it was found, but conversely they are more subject to embrittlement characteristics.

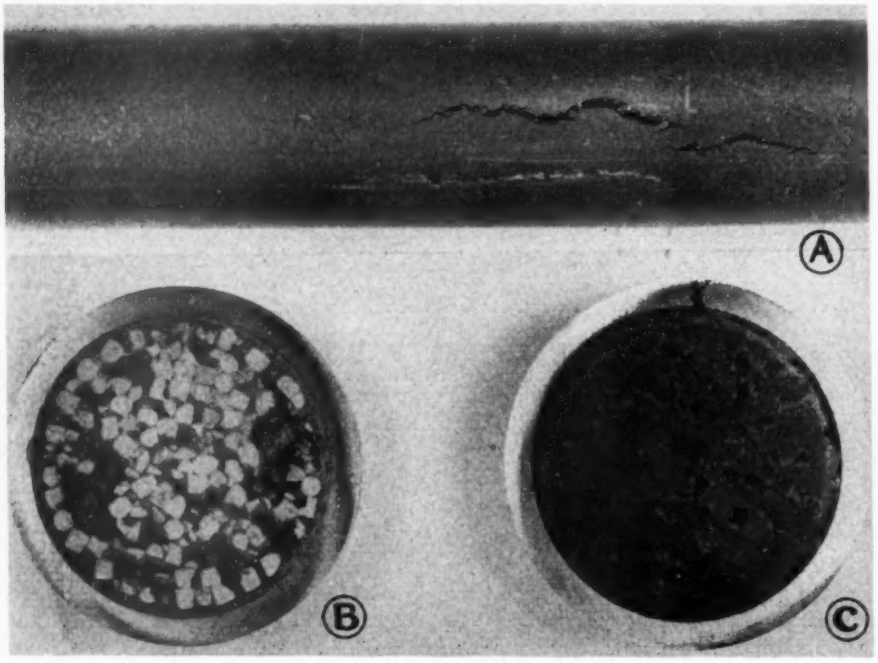
A 29-9 Cr-Ni cast alloy valve in service at the Plains plant of Phillips Petroleum Co., failed under service conditions which involved intermittent heating to 1100° F. by periodic fluid flow through the valve. The valve was found to be almost completely devoid of ductility as a result of sigma phase precipitation.

Another test at the Phillips Plains plant involved two Inconel catalyst tubes in dehydrogenation service. These tubes were installed in a catalyst harp with 27% chromium-iron tubes. It was found that the alloy possessed fairly good chemical resistance with but little scaling or surface attack. However, carbon formation occurred within the tubes plugging them with the result that they cracked badly, as seen in Fig. 6.

Four high temperature steels were tested in contact with natural gas to determine the relative resistance of each to carburization and thus indicate their suitability for gas cracking service. These studies, made at Purdue University by Babcock & Wilcox and Phillips Petroleum, were on 18-8 Cr-Ni, 18-8-Si, Cr-Ni, 25-20 Cr-Ni, and 27 Cr-iron alloys. Temperatures of 1400° F. and 1500° F., and time periods of 100, 500, and 1000 hours were employed.

It was concluded that the rapid rate at which carburization proceeds in the 18-8 and the 18-8-Si materials indicates that these steels would not be suitable for gas cracking service at temperatures approaching 1400 and 1500° F. The 25-20 alloy offered somewhat greater resistance although considerable carburization was evident in the 1000-hour test at 1500° F. The 27% alloy is suitable as far as carburization is concerned, but it does develop a susceptibility to embrittlement.

Fig. 6—Samples of Inconel alloy catalyst tubes after 70 days' service in First Step Dehydrogenation unit at Plains plant, Borger, Texas, of Phillips Petroleum Co. (A) Some of the larger cracks formed when the tube ruptured because of plugs of unregenerated catalyst. (B) Cross section of one tube with plugged catalyst. Tube had been heated in air in a laboratory muffle for 20 minutes at 1400 F. to burn off the carbon. (C) Cross section before such regeneration treatment, showing both plugged catalyst and excessive carbon deposition



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"Properties and Characteristics of 27% Chromium-Iron," H. D. Newell, *Metal Progress*, May, (1946).

The following reports selected from those of the Metals Research Program of the Rubber Reserve Co., now Office of Rubber Reserve, Reconstruction Finance Corp.:

"27% Chromium-Iron Reactor Tubes from Heysham Plant, England, Universal Oil Products Co." Laboratory Report No. RR-4-6, M. A. Cordovi.

"27% Chromium-Iron Alloy Plate from Catalyst Vessels, Butadiene Plant, Sun Oil Co., Toledo, Ohio," Laboratory Report No. RR-4-3, Z. E. Olzak.

"An Investigation of the Cause of 885 F. Brittleness in 27% Chromium-Iron Alloy," Laboratory Report No. RR-3-1, and Supplement 1, J. J. Heger.

"Metallurgical Examination of 25-20 Alloy and 18-8-Silicon Alloy Catalyst Tubes, 1st Step Dehydrogenation, Phillips Petroleum Co., Borger, Texas," Laboratory Report No. RR-4-5. J. J. Heger.

"Failure of 29% Chromium-9% Nickel Cast Alloy Valve, Phillips Petroleum Co., Bartlesville, Oklahoma," Laboratory Report No. RR-4-7, M. A. Cordovi.

"Inconel Catalyst Tubes, 1st Step Dehydrogenation, Plains Plant, Phillips Petroleum Co., Borger, Texas," Laboratory Report No. RR-4-4. Z. E. Olzak.

"Carburizing Effect of Natural Gas Upon High Alloy Steels at Elevated Temperatures—EMD 513," Laboratory Report No. D-90, and Supplement No. 1, Z. E. Olzak.

"The Effect of Time and Temperature in Removing 885 F. Embrittlement in 27% Chromium-Iron Alloy," Laboratory Report No. RR-3-7, J. J. Heger.

"The Effect of Temperature upon the Hardness of Croloy 27," Laboratory Report No. D-91, Z. E. Olzak.

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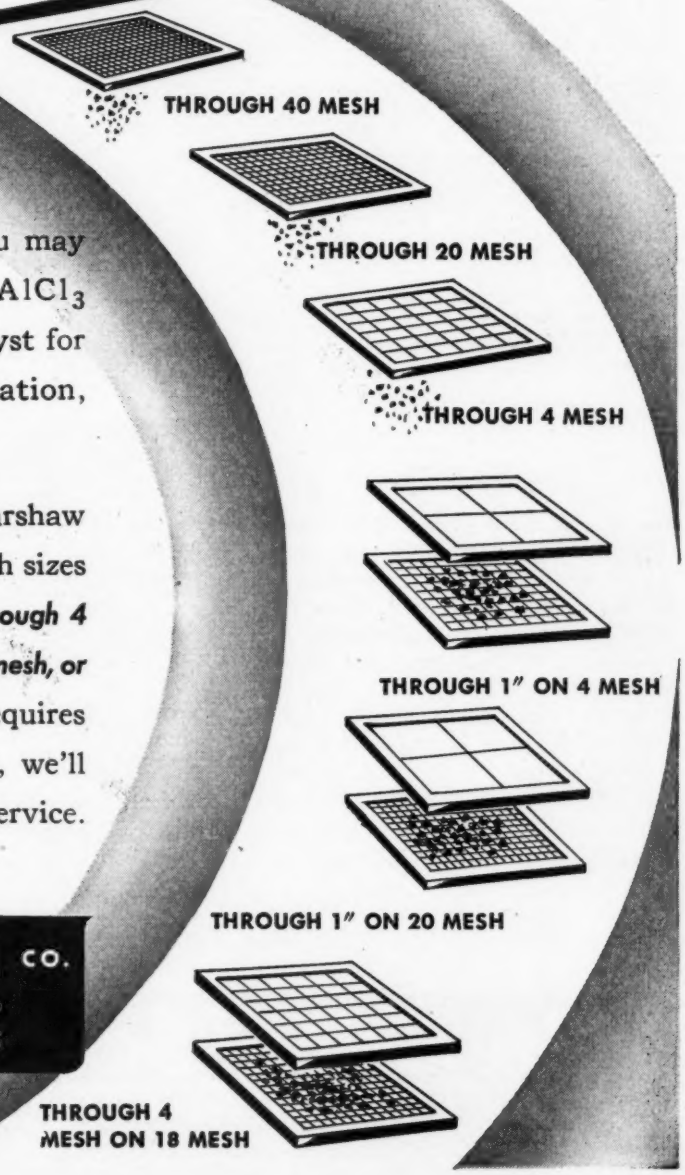

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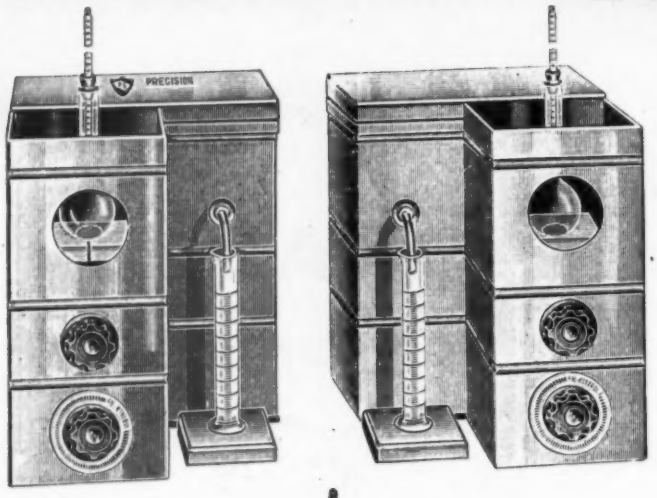
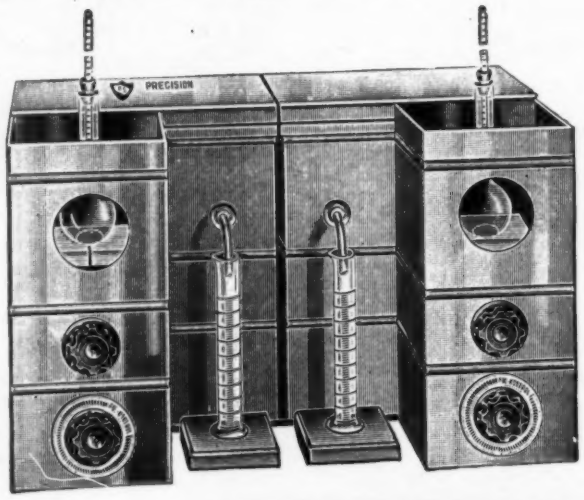


"Precision" Front View Distillation apparatus, single unit with Shield at either right or left of condenser outlet. Includes two porcelain refractory blocks with 1¼" holes and wood block for supporting cooling jar and graduate. Total length 14½"; 18½" from front to rear.

Double unit assembly showing right and left-hand unit as an assembly. Total length 29"; 18½" from front to rear.

Four unit assembly. Total length only 57½". Note all controls out in front; flask observation windows; hinged, insulated cover for condenser trough.



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Flexibility of design allows Front View to be assembled in single and double bank in any desired numbers. An exceptionally useful set-up for the growing petroleum laboratory.

FEATURES

The electric heat source is a built-in "Precision" Ful-Kontrol heater utilizing an automatic transformer allowing practically stepless control up to 750 watts maximum. To compensate for differences in glassware, the height of the flask refractory is adjusted by a handy knob on the front of the shield. Condenser is equipped with a drain outlet rubber binding on bottom of both shield and condenser prevents marring of table tops.

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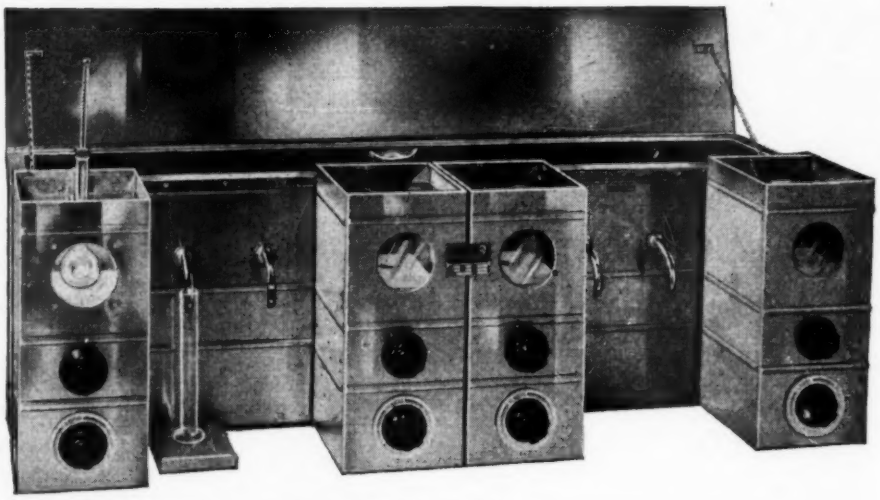

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Insulating Boiler Headers Can Be Profitable

MANY a plant superintendent who is most painstaking in the insulation of his steam lines, fittings, boiler drums and other hot surfaces, either neglects or avoids one very important source of steam boiler heat loss because he lacks the understanding of just how to treat it —the boiler header.

The extreme importance of insulating boiler heads studded with numerous safety hand-hole covers becomes apparent when it is realized that the true radiation area of such a header is generally 2 or 3 times the apparent area. The average safety-hole cap is 3 in. in diameter by 2 in. deep, spaced only 1½ in. apart. One calculation on a moderate size boiler header with a nominal area of 12 sq. ft., revealed a true radiation surface of 30 sq. ft.

As an example, consider a boiler with an average header temperature of 400° F., which, accordingly, would have an uninsulated radiation loss of approximately 1000 Btu/hr./sq. ft. If the head were properly insulated this heat loss could be reduced to approximately 80 Btu/hr./sq. ft.—a heat conservation of some 920 Btu/hr./sq. ft. Over the 30 sq. ft. true radiation surface of the header, the total heat conservation would be 27,600 Btu/hr.

During the course of a year, the approximate savings would amount to 242,000,000 Btu's. Considering that the average fuel oil contains about 13,000 Btu/gal. and that the boiler burner operates at 60% efficiency, the annual savings are equivalent to nearly 2800 gals. of oil, worth, at 5c per gal., $140.

Boiler headers studded with hand-hole covers present extremely irregular surfaces which at first glance seem difficult to insulate. Further, it is erroneously often thought that maintenance crews cannot get at hand-hole covers quickly and easily if they are covered by insulation.

Neither factor, however, need preclude simple and effective protection from heat loss.

One technique involves the use of a mineral wool cement which can be applied so as to fill the recesses of each hand-hole cover, can be smoothed freely over the flange projection of each hand-hole cap, and can be built up to whatever thickness is most economical. When it becomes necessary to knock out any one or a group of covers, it is a simple matter to break away the insulation in the vicinity, save it, and reapply the selfsame cement after the cap is replaced.

To prepare mineral wool insulation the cement is mixed with water to the degree that a small amount of liquid can ooze through the fingers when a quantity of the paste is clutched in the hand. Application is by simply spotting (throwing on by hand) a sufficient quantity to trowel to a thickness of 3/4 to 1 in. After the first coat is dry, the process is repeated until the desired thickness is achieved. It is claimed that adhesion to steel will exceed 3 psi, and that the cement will withstand temperatures up to 1500° F. with no physical or chemical change.

Because of the relatively long fibre of mineral wool insulations, it is possible to withdraw patches of the cement for boiler maintenance and inspection at any point. After the hand-hole covers are replaced, it is merely necessary to crumble up and reapply the cement as though it were new material.

It is believed by the Industrial Mineral Wool Institute, which supplied the above data, that boiler header insulation should be of most interest to those oil refineries where small and medium size steam generation units are common but are not favored with too much advanced steam plant practice.

Typical boiler header with safety hand-hole covers spaced on 4½-in. centers, showing method of applying insulation to thickness of 2 ins. so that it fills all recesses and covers all minor protrusions. At header temperature of 400° F., such treatment reduces heat loss to 80 Btu/hr./sq. ft.

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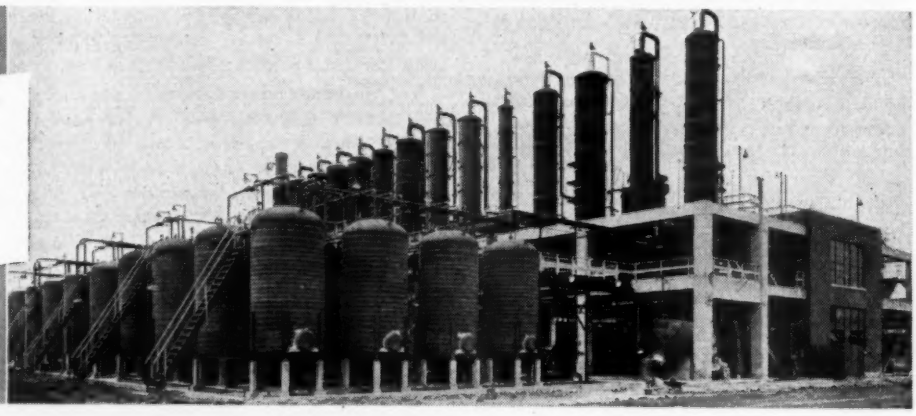
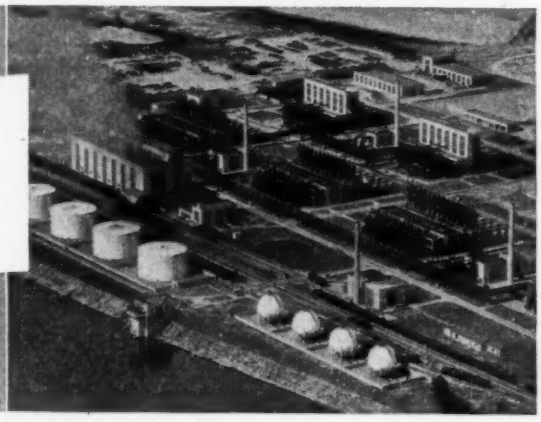
War Assets Administration invites proposals for the outright purchase of any two of these three plants, in whole or in part. The third may be purchased or leased subject to future defense stipulations. Processing units in all three of them are suitable for dismantling and re-erection elsewhere.

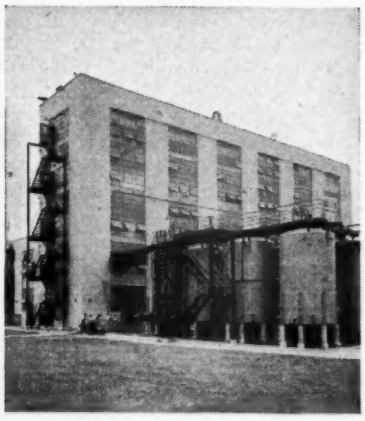
Submit proposals on whichever plant best meets your requirements or contains processing units and equipment you need. Credit terms may be arranged. Information contained herein is not intended for use as a basis for negotiation. The War Assets Administration reserves the right to reject any or all proposals.

Butadiene Plant, Louisville, Ky.

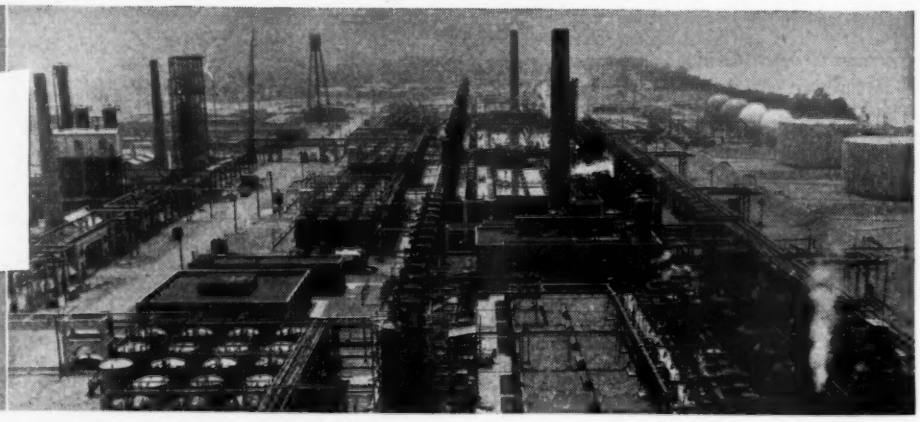


Butadiene Plant with Adjacent Styrene Plant, Institute, W. Va.





Butadiene and Power Plant, Kobuta, Pa.



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Functional Units Comprising Distillation, Fractionation and Catalytic Process Equipment, Easily Convertible to Manufacture of Various Chemical Products

1

PLANT: Plancor 1207 consists of land, buildings, machinery, and equipment for the manufacture of Butadiene from industrial alcohol. The following buildings, of permanent type construction and with a total floor area of approximately 156,000 sq. ft., house the functional units which comprise the three 20,000-ton units: Two Dowtherm furnace buildings, 3 distillation conversion buildings, 2 catalyst manufacturing buildings, together with other smaller service buildings.

UTILITIES: Process water is obtained from the Ohio River. Five centrifugal, motor-driven pumps, located in a pumping station, are capable of delivering a total of 78,000 g.p.m. at approximately 50 lbs.

Domestic water is obtained from 2 driven wells, each equipped with electric-driven pumps.

Process steam is furnished by a high and low-pressure plant with a combined total rated capacity of 700,000 lbs. steam per hour.

Electricity and gas supplied by the Louisville Gas and Electric Company.

TRANSPORTATION: Rail, water and highway transportation available.

★ ★ ★ ★ ★

2

PLANT: Plancor 229 consists of land, buildings, machinery, and equipment for the manufacture of Butadiene from ethyl alcohol. The production area comprises 4 units for conversion, each unit having rated capacity of 20,000 short tons per annum; 2 Dowtherm furnace buildings; a catalyst building; a water treating building; 2 water pump houses; 5 foam houses; a switch room; a machine shop; a stores building; totaling 270,000 sq. ft. floor area. All structures of permanent type.

UTILITIES: Water-cooling and fire protection water is pumped from the Kanawha River from two identical pump houses, each containing 6 electric-driven centrifugal pumps with total capacity of 66,000 g.p.m. and one steam turbine-driven, centrifugal pump with capacity of 11,000 g.p.m. A 2,000 g.p.m. treating plant provides treatment for boiler water.

Steam boiler plant comprises rated capacity of 750,000 lbs. of steam per hour at 415 p.s.i. Complete with pulverized coal, oil and/or gas firing.

Electricity and natural gas supplied by public utilities.

TRANSPORTATION: Rail, water and highway transportation available.

PLANT: Plancor 1055 consists of land, buildings, machinery, and equipment for the manufacture of Styrene from ethylene secured from others by pipe line. The rated capacity is 25,000 short tons of Styrene per annum. The production area comprises 2 Styrene distillation units; Tetralin furnace building; one catalyst building; totaling approximately 40,000 sq. ft. floor area.

UTILITIES: Available from the adjacent Butadiene plant.

★ ★ ★ ★ ★

3

PLANT: Plancor 483 consists of land, buildings, machinery, and equipment for the production of 80,000 short tons of Butadiene from alcohol feed stock annually. Production area includes 4 identical Butadiene productive units, each rated at 20,000 tons annual capacity; 2 Dowtherm units. Each Dowtherm building contains two Dowtherm Vaporizers (gas or oil-fired) rated at 24,000,000 b.t.u. per hour, surge tanks and two Methane gas compressors with auxiliary pumps.

The power plant building contains boiler bay, turbine bay, powerhouse annex, and there are 11 substations. The boiler bay contains 4 boilers, 350,000 lbs. steam per hour continuous rating each, at 800 lbs. per sq. in. Steam passes either through a 35,000 kw Westinghouse "Topping" turbogenerator unit, or through a battery of reducing stations which reduce the pressure from 750 p.s.i. to 165 p.s.i. Designed capacity of turbogenerator is 43,750 kw at 80% power factor, ½ lb. hydrogen cooling pressure. Powerhouse annex receives coal by conveyer or chute from main boilerhouse and contains one Combustion Engineering, four drum, natural circulation boiler, 200,000 lbs. steam per hr. total capacity at 450 p.s.i. saturated temperature, with tubular air heater, combination forced and induced draft fan, Raymond fuel pulverizing equipment and 2 Allis-Chalmers boiler feed pumps.

UTILITIES: Water for industrial and fire protection purposes is pumped from the Ohio River. Drinking water is obtained from 2 deep wells.

Electric power and light is obtained from the generating station adjacent to the boilerhouse.

TRANSPORTATION: Rail, water and highway transportation available.

ADMINISTRATION

PROPERTY DISPOSAL

WASHINGTON 25, D. C.

901-T

Proportioning Valves Speed Blending of Gasoline, Eliminates Mixing Tanks at Pipe Line Terminal

NO BLENDING tank facilities have been needed for any of the natural gasoline products loaded at the Phillips Petroleum Co. East Chicago pipe line terminal since it was built in 1939.

The desired grade of gasoline is blended directly into tank cars, tankers and pipe lines by means of diaphragm-operated proportioning valves. As an example: by use of the valves any grade of natural gasoline from butane-free 12 lb. RVP to 26 lb. RVP can be blended and loaded directly by pumping the proper proportions of 12 lb. and 26 lb. naturals through the valve.

Thus, a last minute change in specifications can be taken care of by simply changing the setting on the valve, which reads in percentage by volume. The valve is not limited in use, however, to the grades given in the example.

Phillips has two 6-in. proportioning valves on the central manifold and three 3-in. proportioning valves on the tank car loading rack at the East Chicago terminal. They are installing two more of the smaller size—an additional one on the tank car loading rack, and one on the tank truck loading rack.

The two large valves in the central manifold are used for tanker loading and pipe line deliveries. Using two 1000-gpm centrifugal pumps and about a half mile of 8-in. pipe, the gasoline blend is loaded into tankers at about 2000 bbls./-hr. Tankers between 18,000 and 45,000 bbls. capacity are loaded from the East Chicago terminal.

By pumping through the two 6-in. valves in a series arrangement a blend of three different gasolines can be made. The mixture of two grades from the first valve is proportionately mixed with the third component in the second valve.

The proportioning valve maintains the proper blend for which it has been set even though pump or inlet pressures may vary. It eliminates the necessity of measuring desired quantities into a tank by float levels, sticks, or other devices, and it also removes the need for batch agitation. In the case of gasoline blends, there is not only a saving in time, but also elimination of expensive vapor loss that occurs in the air agitation process.

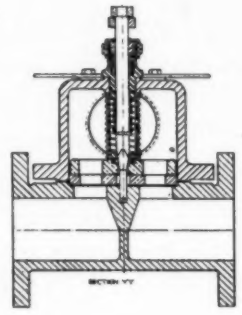
Maintains Equal Inlet Pressures

A cross section view of the valve is shown in Fig. 1. The two liquids to be blended are brought to the pressure equalizing valves C_1 and C_2 the function of which is to maintain equal pressures at the inlets to the proportioning valve. This pressure is transmitted back to the diaphragm operated valve assembly through lines B_1 and B_2. Should the pressure at A_1 tend to increase slightly over the pressure at A_2, the diaphragm will be moved to the left, because of the pressure differential in the control pipes. As a result the area of valve opening C_1 will be reduced and C_2 increased, again balancing the pressures at A_1 and A_2.

Since the two pressures at A_1 and A_2 are maintained constant by the equalizing valve, the percentage of the two

TABLE 1—Results of individual tests by Fisher Governor Co. on actual loading of 18 tank cars with a blend of 58 lb. and 12 lb. RVP gasolines

Test No.	Calculated % 58 lb. RVP	Valve Setting	Line Pressure, psi. 12 lb.	Line Pressure, psi. 58 lb.	Inlet Pressure, psi. 12 lb.	Inlet Pressure, psi. 58 lb.	Outlet Press., psi.	Product RVP Desired	Product RVP Actual
1	29.35	29.5	70	40	38.5	38.5	28	25.5	25.4
2	29.35	29.5	71	41	39.0	39.0	29	25.5	25.5
3	29.35	29.5	71	41	39.0	39.0	29	25.5	25.3
4	29.35	29.5	72	43	41.0	41.0	31	25.5	25.3
5	29.35	29.5	71	42	40.0	40.0	30	25.5	25.4
6	29.35	29.5	71	42	39.5	39.5	30	25.5	25.3
7	29.35	29.75	73	40	38.5	38.5	28.5	25.5	25.4
8	29.35	29.75	73	41	39.0	39.0	29	25.5	25.5
9	29.35	29.75	72	38	36.0	36.0	25	25.5	25.5
10	29.35	29.75	No Pressures Taken					25.5	25.3
11	29.35	29.75	No Pressures Taken					25.5	25.5
12	29.35	29.75	No Pressures Taken					25.5	25.5
13	29.35	29.75	No Pressures Taken					25.5	25.3
14	29.35	29.75	No Pressures Taken					25.5	25.4
15	29.35	29.75	No Pressures Taken					25.5	25.4
16	29.35	29.75	No Pressures Taken					25.5	25.1
17	29.35	29.75	No Pressures Taken					25.5	25.3
18	29.35	29.75	No Pressures Taken					25.5	25.6



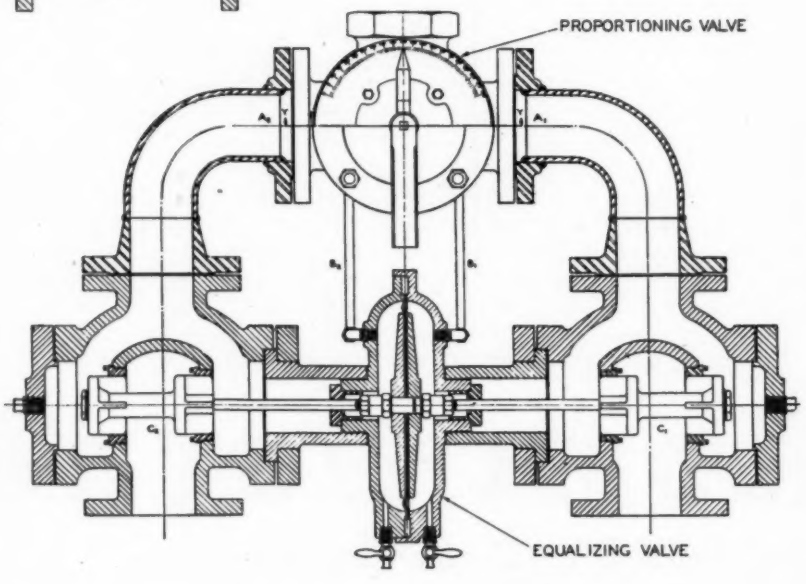


Fig. 1—Cross section view of 3-in. blending valve. As shown, flow is from bottom to top. Variations in pressures at A_1 and A_2 are transmitted through lines B_1 and B_2 to Neoprene diaphragm which in turn varies area of passages at valves C_1 and C_2. Proportional percentage of the two components which flow through the valve is controlled by setting the vernier pointer, which moves from zero to 100

The critical component in rust preventive compounds

EACH component of a compounded rust preventive oil is manifestly a critical one. This is axiomatic. Yet evidence shows conclusively that efficient rust prevention requires an effective inhibitor in order to protect adequately under severe conditions.

Emery's X-260, for example, meets these critical requirements. Such a base when blended into formulas containing other components necessary to fulfill the "working" conditions imposed upon corrosion resistant products . . . meets the demands of Government specifications and the requirements of proprietary compounds.

Oils and greases designed to resist corrosion, and other metal-working compounds as well, are prepared by manufacturers of lubricating specialties, using Emery Bases which have been developed and pre-tested in Emery's laboratories.

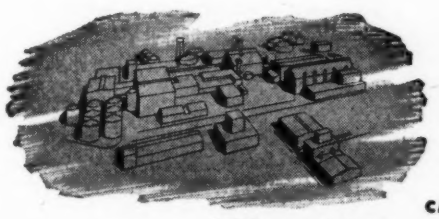
Write for detailed recommendation of the Emery Base best suited to your particular need.

Characteristics of Emery's Rust Preventive Concentrate X-260

Sap. Value	145-155 max.
Acid No.	6% max.
Volatility	Not more than 1.0% by weight @ 210° F. for 3 hours
Compatibility	Compatible with lubricating oils and most hydrocarbon compounds and common organic solvents.

In general, corrosion resistance except where parts are hermetically sealed, depends upon the presence of an active inhibitor compounded with vehicles . . . whether oils, waxes, or greases . . . of the types necessary to withstand the physical requirements of exposure and handling of the object protected.

Emery Bases for corrosion resistance and other metal-working compounds are built and tested for specific uses.



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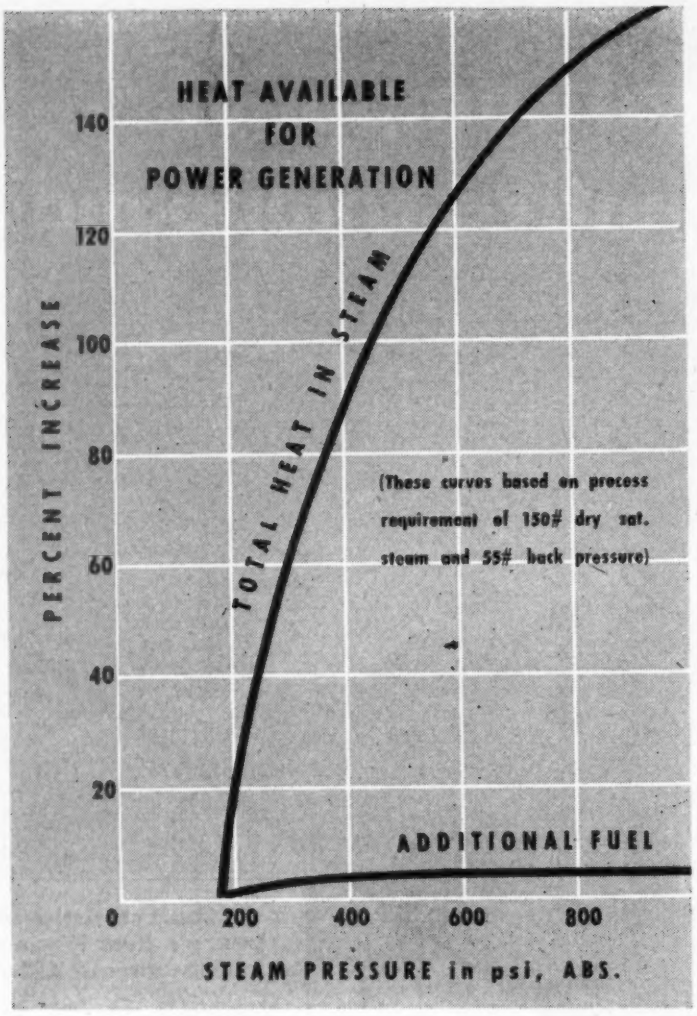

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A Kuljian Survey will determine quickly the extent to which such opportunity exists in your operations. Kuljian Engineers have specialized for years in power plant design and construction. It may pay your company large dividends to take advantage of this service. Your inquiry is invited, now.

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liquids being blended will be dependent on the opening of the disc area within the proportioning valve.

The valve body of the disc type blending valve has a dividing wall separating the two inlet sides. A connection from the inlet to outlet passage is covered by a flat disc plate with areas designed to control the flow of the two liquids in definite proportions as indicated by the scale.

For example, when the pointer is set at zero, the passage from point A_1 is wide open, and the left hand passage at A_2 is completely closed; when the pointer is set at 100, the flow condition is exactly reversed.

Should the pointer be set at 25 on the scale, the blended product would consist of 25% fluid entering at A_2 and 75% fluid entering at A_1. These percentages are accurately maintained because the pressures at the inlets to the blending valve are held identical by the pressure equalizing diaphragm operated valve.

The unit was developed in co-operation with Phillips engineers by the Fisher Governor Co. for use in such installations as that at East Chicago. There are a number of these units on the Phillips products pipeline from Borger, Texas, to East Chicago.

Tests Prove Efficiency of Valve

A series of tests on tank car loadings have demonstrated the operating efficiency of the valve. Table 1 shows the results of 18 individual tests on 18 tank cars of gasoline blended from 58 lb. RVP and 12 lb. RVP gasolines. The desired product was one of 25.5 lb. RVP. Finished tank car blends ranged from a low of 25.1 lb. RVP to a high of 25.6 lb. RVP. Although line pressures of the two components were about 40 psi for the 58 lb. gasoline and about 71 psi for the 12 lb. gasoline, the inlet pressures at the blending valve were kept to equivalent figures by the diaphragm valve.

Differential pressures at points A_1 and A_2 of from minus 0.18 to plus 0.07 psi were obtained in laboratory tests. The results, shown in Table 2, indicate that, even though the inlet pressures may vary considerably, the pressure differential across the vernier metering valve will remain relatively constant.

The diaphragm in both the small and large size valves is Neoprene. The 3-in. valve has a maximum pressure rating of 100 psi, and the 6-in. valve a maximum pressure rating of 150 psi.

TABLE 2—Results of laboratory tests on the efficiency of the pressure equalizing valve.

Supply Line Pressure, psi. At C_1	Supply Line Pressure, psi. At C_2	Rate of Flow, gpm.	Differential Pressure, psi.
78	38	232	—0.08
75	65	300	—0.18
73	73	318	—0.02
65	75	299	+0.07
37	77	230	+0.07

Disposal Needs Based on Graph Method For Finding Run-Off to Rainfall Ratio

Article 14 in a Series—By W. B. HART
In Charge of Waste Disposal for Atlantic Refining Co.

Graphical methods of determining the ratio of run-off to rainfall ratio over various kinds of surfaces are important to refiners in modernizing their waste disposal systems. Procedures described are applicable to existing plants as well as to those in the design stage. Whole areas can be measured with reasonable accuracy when soil and surface conditions are known. Knowledge of peak loads in storm run-off and process waste flow rates is essential to the planning of treatment facilities.

This discussion is a conclusion of the subject "Estimation of Storm Run-off" appearing in previous issues of PETROLEUM PROCESSING.

TYPICAL drainage areas in the refinery, which are to serve as examples for demonstrating the estimation of run-off, should include areas which are paved completely, areas such as those on tank farms, and areas in between these extremes. The completely paved areas will be considered first.

A completely paved area obviously will permit no infiltration. Consequently, only evaporation and surface retention will tend to reduce the quantity of water which will move to the sewer inlets, and the rate at which it will arrive. If the area is properly curbed, no water will flow to neighboring ground.

But if it is not curbed, and water does flow to such neighboring areas, the effects of their surface conditions must be taken into consideration, and any infiltration and surface retention properly applied in the estimate. Sewer inlets, which by their location will contribute to the rate at which the water will be carried away, also must be included with those in the paved area. Grade differential, distance to sewer inlets, and distribution of the inlets all must be taken into account.

An area such as that described is illustrated in sketch plan in Fig. 1. Tanks, towers, and pump or control houses are shown. Pipe lines, railings, structural steel, and so forth, are not shown, but should be assumed and included as wetted surfaces. Sewer inlets are marked. For more complete illustration some outer area is included.

When rainfall begins, the run-off from such an area is not apparent immediately but does start very soon thereafter. Roof drains begin to deliver flow to the sewer almost at once if the rain is heavy. The

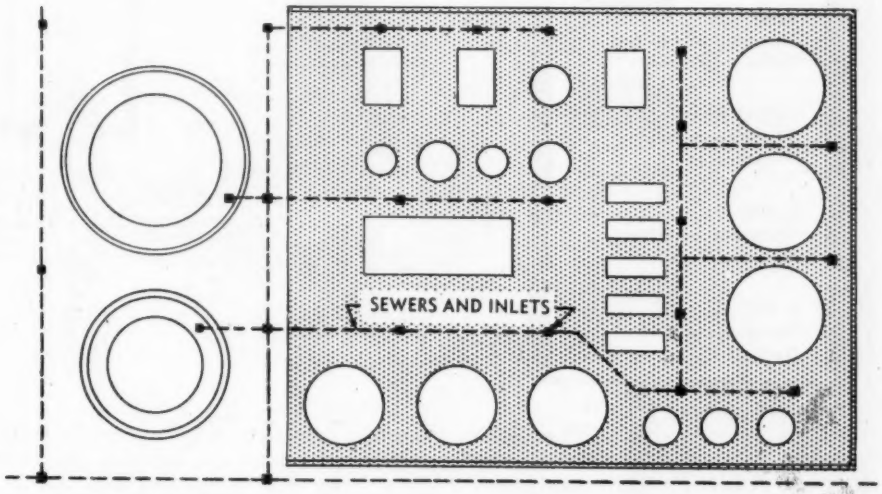

Fig. 1—A typical paved area and adjacent unpaved area in a small refinery. In paved area are furnaces, towers, a pump and control house, running tanks, and a continuous treating plant. Crude tanks are in unpaved area

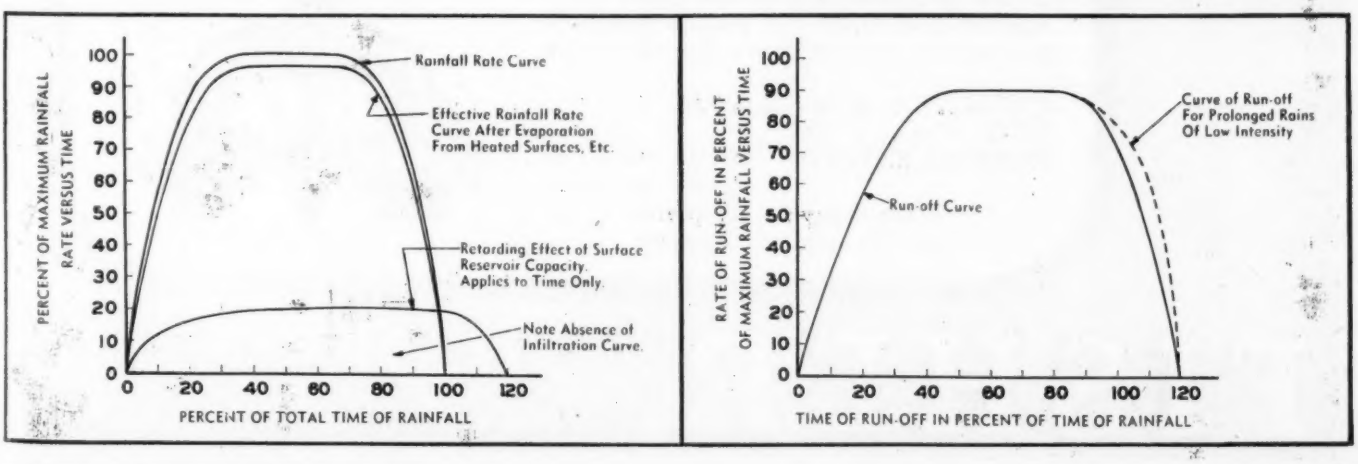
PERCENT OF MAXIMUM RAINFALL RATE VERSUS TIME
Rainfall Rate Curve
Effective Rainfall Rate Curve After Evaporation From Heated Surfaces, Etc.
Retarding Effect of Surface Reservoir Capacity. Applies to Time Only.
Note Absence of Infiltration Curve.
PERCENT OF TOTAL TIME OF RAINFALL
RATE OF RUN-OFF IN PERCENT OF MAXIMUM RAINFALL VERSUS TIME
Curve of Run-off For Prolonged Rains Of Low Intensity
Run-off Curve
TIME OF RUN-OFF IN PERCENT OF TIME OF RAINFALL

Fig. 2—Graphs for estimating run-off from fully paved refinery such as shown in Fig. 1. Upper graph gives rainfall rate curve. Lower graph gives curve for rate of run-off in per cent of maximum rainfall

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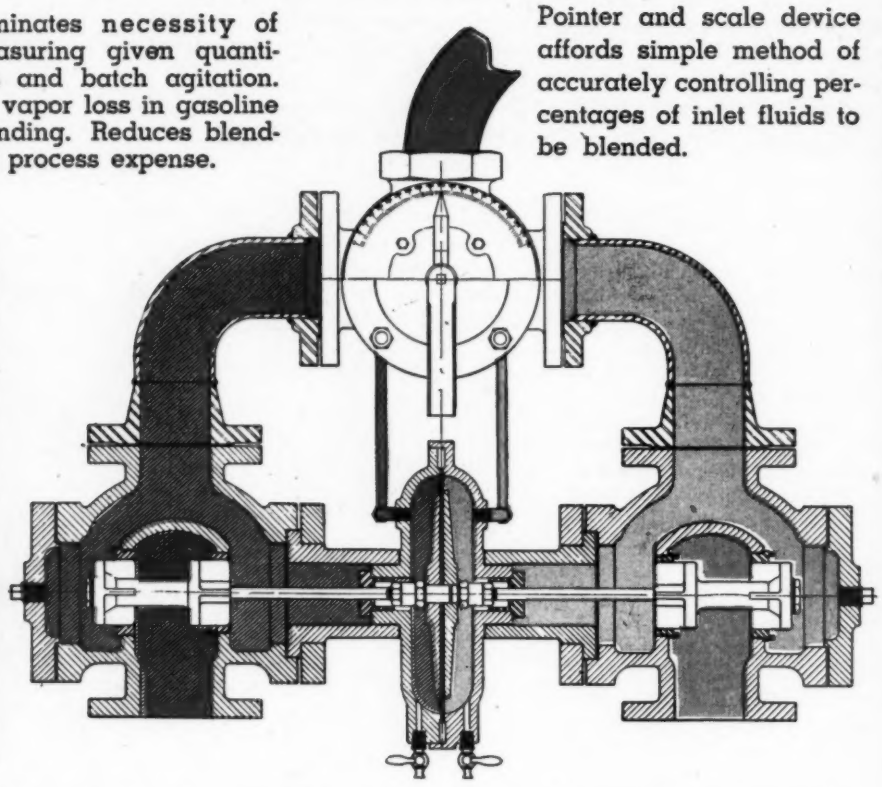
Eliminates necessity of measuring given quantities and batch agitation. No vapor loss in gasoline blending. Reduces blending process expense.

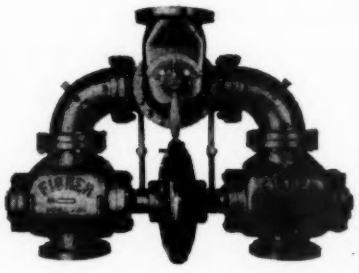
Pointer and scale device affords simple method of accurately controlling percentages of inlet fluids to be blended.

LEGEND

- FLUID A Fluctuating Inlet Pressure
- FLUID A Constant Equalized Reduced Pressure
- FLUID B Fluctuating Inlet Pressure
- FLUID B Constant Equalized Reduced Pressure
- FLUID C Blended Fluid of Desired Characteristics



The Fisher Type 430 Blending Valve is particularly designed to automatically —and with accuracy—control blending processes common to the petroleum industry. Fluids from two different storage tanks are accurately blended even though pump or inlet pressures vary. Liquids to be blended are brought to the pressure equalizing valves, which maintain equal pressure at both inlets of the proportioning valve. This valve controls flow of the two liquids in definite proportion as indicated by the scale.



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PRESSURE RATING: 3", 100 lbs. per sq. in.
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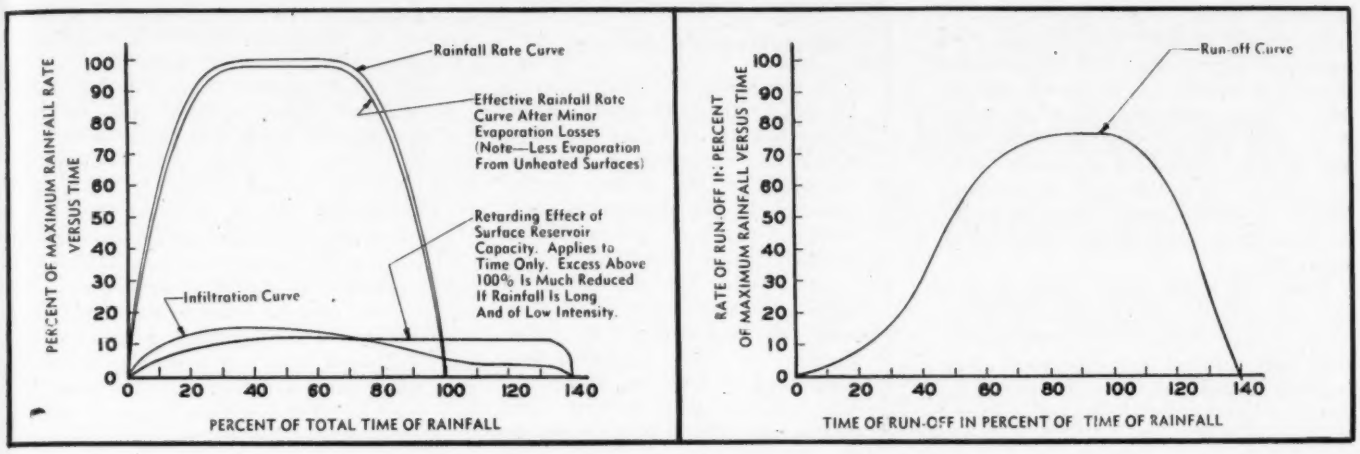

PERCENT OF MAXIMUM RAINFALL RATE VERSUS TIME
Rainfall Rate Curve
Effective Rainfall Rate Curve After Minor Evaporation Losses (Note—Less Evaporation From Unheated Surfaces)
Retarding Effect of Surface Reservoir Capacity. Applies to Time Only. Excess Above 100% Is Much Reduced If Rainfall Is Long And of Low Intensity.
Infiltration Curve
PERCENT OF TOTAL TIME OF RAINFALL
RATE OF RUN-OFF IN PERCENT OF MAXIMUM RAINFALL VERSUS TIME
Run-off Curve
TIME OF RUN-OFF IN PERCENT OF TIME OF RAINFALL

water from tank roofs and towers will spill to the ground and start flowing to the sewer inlets together with the water on the ground. All surfaces will be wetted and some evaporation will take place. Pools may form and evaporate later. Foundations and similar structures may retard flow by interfering with direct paths to the sewer inlets.

All these things must be considered in formulating a basis for the estimate if the refinery is only in the design stage, or must be studied in any existing plant.

The run-off pattern in terms of percentage of the rainfall, and in its time relationship, will be relatively constant. A pattern for the area described is that shown in Fig. 2. The pattern for the area outside the paving also is shown in this figure. It should be noted that relatively little of the rain is eliminated from the run-off by evaporation or ground storage, but the retarding effect of surface condition and structures will be evident.

The combined percentages of the total rainfall which are developed for the two areas will give the total run-off. The rate of run-off will be the total run-off divided by the time it occupies, as indicated by the base length of the simple hydrograph. This also is true for any increment of time, selected from the run-off curve, and applied to the percentage scale.

Fig. 3—Plot for estimating run-off from medium hard surface, such as around equipment. The ground surface is not paved, but is the well-packed surface usual in roadways, but with areas of normal soil density also. Infiltration is small in such areas

It should be remembered that the above estimation procedure is applicable only up to the sewer inlets. Once the run-off is in the sewer, the flow velocity and length of sewer to the point of accumulation must be estimated. This should not prove to be difficult for the plant personnel. If the sewer exists, the velocity can be determined fairly well by dyes or floats of wood. The period of time estimated for the flow in the sewer is an extension of the run-off time estimated from the simple hydrograph. There will be no increase in volume.

Estimate for Small Refinery

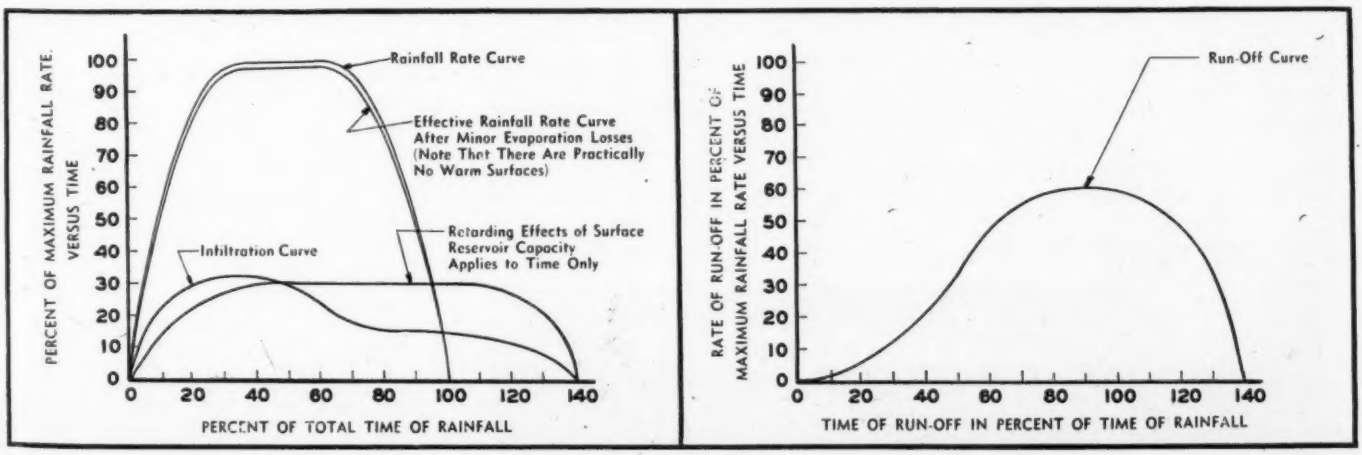
With understanding of the simple hydrograph method for estimating quantity, time, and rate of run-off, it will be necessary only to show various simple hydrographs for example areas, and present brief explanations. One of these will show a small refinery in its entirety. The personnel of any plant then must use careful judgment in applying the methods presented. The judgment should be conservative, for if it is not, and the estimate is used in treatment plant design, the plant may give results which are unsatisfactory to regulatory agencies. Then expensive capacity additions may be required which originally could have been provided cheaper.

Fig. 3 shows the relationship of run-off to rainfall in an area of normal equipment density where there is no paved area. The ground surface assumed is the well packed surface usual in roadways and around the units, but with areas of normal soil density also. The ratio of this normal soil surface to the packed surface is a determining factor in moving the run-off curve upward or downward, for infiltration in the packed surface area is both small and slow.

Many smaller refineries can be described in this way. It should be understood, however, that any undeveloped areas, or tank farm areas, are not included. Such areas should be estimated separately, and added to the estimated run-off from the small refinery area.

The run-off from areas of this nature will not be as great, nor will it accumulate as rapidly at a given point (e.g., a

Fig. 4—Plot for estimating run-off from tank farm and similar areas where the surface is grass or the like. In this case, infiltration and surface reservoir capacity indicate their greatest effect in reducing and retarding run-off


PERCENT OF MAXIMUM RAINFALL RATE VERSUS TIME
Rainfall Rate Curve
Effective Rainfall Rate Curve After Minor Evaporation Losses (Note That There Are Practically No Warm Surfaces)
Retarding Effects of Surface Reservoir Capacity Applies to Time Only
Infiltration Curve
PERCENT OF TOTAL TIME OF RAINFALL
RATE OF RUN-OFF IN PERCENT OF MAXIMUM RAINFALL RATE VERSUS TIME
Run-Off Curve
TIME OF RUN-OFF IN PERCENT OF TIME OF RAINFALL

treatment plant), as will be the case in fully paved areas. But actually the packed or hard surface will act in almost the same manner as a paved surface, and if there are numerous sewer inlets, it may be that a more accurate estimate will be obtained if the packed areas are treated separately and in the same manner as paved areas. Then the more pervious areas also can be treated separately.

It will be necessary to judge the degree of infiltration carefully. This degree will lie between that of the heavily used areas around the equipment zone, and the rather extensive infiltration of the open grass covered areas of the tank farm.

There will be one feature of note in areas of this nature, however. As a result of the rougher surface, and the obstructions to surface flow in the form of structures, pipe lines, and so forth, the run-off will continue for a longer period of time after cessation of rainfall than occurs with smooth, paved surfaces. This is shown clearly in Fig. 3.

The final type of area to be considered is that usually found inside the fire bank around tanks. Here, infiltration and surface reservoir capacity will show their greatest effect in reducing and retarding run-off. Obviously, since each tank area (i.e. inside the fire bank) usually will have its own sewer inlet, each such area should be estimated separately. However, if a number of such areas definitely are alike, the same volume and rate of run-off may be applied in each case. The run-off from tank areas can be estimated from Fig. 4.

It should be understood that the foregoing procedures are presented only as an aid for *estimating* run-off, and particularly for estimating the run-off when the plant is only in the design stage. The procedures are usable also for existing plants. There will be the advantage of known soil and surface conditions when the refinery exists, but even this knowledge will not make the figures finally obtained any more than an estimate.

As stated earlier, the measurement or estimation of run-off is necessary in order to establish waste treatment plant capacity. The quantity of waste which will result from any particular operation can be measured or can be estimated from a material balance alone or in conjunction with utility records.

But consideration also must be given other factors which will be discussed under waste treatment. The principal point to be made here is that the maximum rate of process waste flow must be known, and to this must be added the maximum rate of storm run-off from any area subject to contamination. The sum will be the quantity of waste for which treatment capacity must be provided.

Next Month's Article . . .

In the article to follow, methods for the treatment of petroleum refinery wastes will be discussed. These discussions will include consideration of the various factors essential to the particular treatment, as well as information on methods being developed which show promise. The wastes will be taken up in the order in which they were tabulated earlier (National Petroleum News, *Technical Section*, April 3, 1946, pg. R-292).

The first of these is waste containing oil, which will appear in the March issue of Petroleum Processing.

Little Literature Available

As stated earlier, there is little or no background of literature or experience directly pertinent to the estimation of storm run-off from industrial areas such as refineries. There have been many articles on run-off from areas of natural cover, and some on run-off from small urban areas. The articles to be found in Transaction of the *American Society of Civil Engineers, Transactions of the American Geophysical Union*, U. S. Government Bulletins, and other publications (149-158) will be of interest. Data on rainfall rates and expectancies are available from the various states and from the Supt. of Documents.

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Superfractionating Base Stocks For 100-Octane Gasoline

Technique for Precise Separation Developed at Abadan Refinery Provides Isohexane from Gasoline and Isoheptane from Naphtha, from Crude Distillation. Operation of Multi-Plate Columns is by Volume Control

This article is a review of an article appearing in the *Journal of the Institute of Petroleum* for April, 1946, entitled, "Process Development and Production of Isohexane and Isoheptane as Aviation Fuel Components", by S. F. Birch, P. Docksey and J. H. Dove, of the Anglo-Iranian Oil Co. It includes later first-hand information on present day operations. Data tabulations and curves are republished by permission of the Institute of Petroleum, London.

SUPERFRACTIONATION of light hydrocarbon streams was utilized to provide one-third of the approximately 25,600 b/d of 100-octane aviation gasoline produced by Anglo-Iranian Oil Co.'s 400,000 b/d Abadan refinery in Iran. Since the war this equipment has continued to operate at full capacity, producing even higher-quality blending stocks for aviation gasoline than during the war to compensate for a reduction in permissible tetraethyl lead content.

Production of the isohexane and isoheptane fractions at Abadan started about the middle of 1943. Maximum production of these iso-stocks, amounting to some 9000 b/d, was achieved in the early part of 1944. The superfractionated base stocks were blended with high-octane material available from production of iso-octane, hydrocodimer, alkylate and aromatic-rich stocks containing toluene and xylenes, the last named being derived from solvent extraction of suitable portions from Iranian crude.

Physical methods, rather than any form of catalytic cracking, was determined upon as a means of providing these high-quality base stocks because it required the least amount of steel per daily barrel of useful product. The entire superfractionation facilities, including exchangers, piping, equipment supports and stagings, used 6300 tons. This is equivalent to 0.7 tons per barrel of blending stock produced.

An unusual method of control, which gives almost laboratory-precision quality products, is used on the majority of superfractionators at Abadan. Due to the small temperature differentials existing between hydrocarbons at the cut points, the usual temperature controls were abandoned in favor of operating by volume control. In this method the quantity of either overhead or bottoms product removed is rigidly based on the proportion of this material present in the feed stock. The other product is removed at a rate sufficient to prevent accumulation in the tower. Flow controllers set on these factors are of the recording orifice meter type. To minimize metering errors, provision is made to maintain constant temperature on feed and products streams entering the meters.

Uniform composition of feedstock is vital to volume control methods. At Abadan large floating-roof tankage facilities are provided for feed and intermediate stocks, permitting adequate time for analysis and filling before the individual tank must go on-stream. Sufficient feed stock of uniform composition is contained in each tank to supply its unit for 4 to 5 operating days.

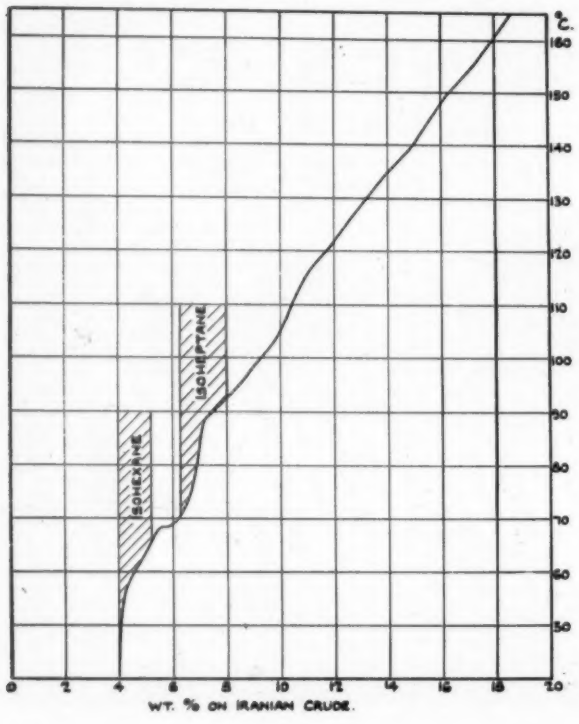

Fig. 1—True-boiling-point distillation on typical Iranian crude. Width of isohexane and isoheptane cuts, used as 100-octane gasoline base stock, is indicated as 1.2 wt.—% and 1.7 wt.—%, respectively

Design Considerations

Considerable exploratory work preceded construction of the equipment for producing isohexane and isoheptane fractions. True boiling point distillation of Iranian crude indicated there were approximately 1.2 wt. % of so-called "isohexane" and 1.7 wt. % of "isoheptane" fractions present, as shown in Fig. 1, which would include hydrocarbons possessing high octane ratings. Specifically, for isohexane this would include compounds boiling between 120.9 and 145.9° F. and embraced those hydrocarbons including benzene boiling between 161.3 and 197.4° F. in the isoheptane fraction. The hydrocarbons included in these boiling ranges are shown in Table 1.

Providing *n*-pentane and *n*-hexane were excluded from the cut, the isohexane fraction would have an octane number not lower than 73, CFR Motor method, and similarly, except for the variable pres-

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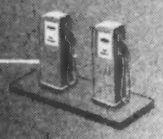

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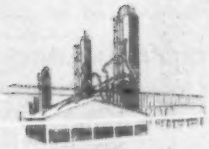

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TABLE 1—Boiling Points and Octane Numbers of Low-boiling-range Hydrocarbons

Hydrocarbon	Boiling Point °C.	Boiling Point °F.	Octane Number C.F.R. MM.
n-Pentane	35.95	96.7	62
Isohexanes:			
cycloPentane	49.4	120.9	85
2,2-Dimethylbutane (neohexane)	49.7	121.3	93
2,3-Dimethylbutane (diisopropyl)	58.0	136.4	94
2-Methylpentane	60.3	140.5	73
3-Methylpentane	63.3	145.9	75
n-Hexane	68.8	155.8	26
Isoheptanes:			
Methylcyclopentane	71.85	161.3	80
2,2-Dimethylpentane	78.9	174.0	93
Benzene†	80.2	176.4	91*
2,4-Dimethylpentane	80.65	177.2	82
cycloHexane	80.8	177.4	77
2,2,3-Trimethylbutane (triptane)	80.9	177.6	113*
3,3-Dimethylpentane	86.1	186.9	84
1,1-Dimethylcyclopentane	88.05	190.5	(80)
2-Methylhexane	89.7	190.7	(45)
2,3-Dimethylpentane	89.9	191.1	89
1,3-Dimethylcyclopentane (trans)	90.5	194.9	(80)
3-Methylhexane	91.9	197.4	(45)
1,2-Dimethylcyclopentane (trans)	91.9	197.4	(80)
n-Heptane	98.4	209.1	0

* Blending octane number.
† Included because of abnormal vapor-liquid relationship between it and *n*-hexane. Parenthetical ratings are estimated.

ence of 2- and 3-methylhexanes, the isoheptane cut should have a high octane value if *n*-hexane and *n*-heptane were excluded.

To produce such cuts commercially it would be necessary to separate between *n*-pentane, boiling at 96.7° F., and cyclopentane at 120.4° F. on the front end of the isohexane fraction and between 3-methylpentane (145.9° F.) and *n*-hexane (155.8° F.) on the back end; differences of 23.7° and 9.9° respectively. For isoheptane, it would be necessary to separate between hydrocarbons boiling 5.5° and 11.7° apart, respectively.

Laboratory distillation on semi-plant scale columns of Iranian naphtha yielded fractions having the inspection data of Table 2. From this it was decided to make an isohexane fraction which would have a rich mixture rating, calculated F4 (3-C) method, of 84 with 4.8 ml. TEL per Imperial gallon, 87 for isoheptane; with the additional restriction on isoheptane of a 5% maximum for material boiling over 203° F., to be sure refinery production would fall inside the desired range of compositions.

The refinery would prepare two base cuts—isoheptane base and isohexane base, respectively—which then would be subjected to continuous superfractionation. The fractionation also would be divided into two operations for each base cut; these are designated "Isohexane Op. 1" (removal of *n*-pentane overhead), "Isohexane Op. 2" (isohexane overhead), "Isoheptane Op. 1" (*n*-hexane and lighter overhead) and "Isoheptane Op. 2" (isoheptane overhead, *n*-heptane and heavier bottoms). If an excessive loss of isoheptane should occur by inclusion in the isohexane base, it could be recovered by passing Isohexane Op. 2 bottoms into isoheptane feed. Conservation of isohexane also could be achieved by reversing this procedure. Fractionators were allocated to these operations as follows:

Isohexane, Op. 1 . . one 50-plate column
Isohexane, Op. 2 . . two 76-plate columns
Isoheptane, Op. 1 . . two 100-plate columns
Isoheptane, Op. 2 . . two 50-plate columns
Spare Unit . . . . . one 50-plate column

The function of the spare unit is either to act as a standby or as an intermediate column operating on Isohexane Op. 2 bottoms, removing *n*-hexane overhead and iso-heptane-containing bottoms as additional feed to Isoheptane Op. 1. As constructed, the columns were uniformly 12 ft. in diameter, contained either 38 or 50 plates on a 2 ft.-6 in. spacing and varied between 120 and 140 ft. high. Two 38-plate columns were series-connected to supply the equivalent of a 76-plate fractionation requirement and two 50's for the 100-plate. Photographs of some of these superfractionators are shown.

The plant first flashes off 7% by volume of the crude as "wild gasoline" and a light naphtha cut (170-230° F.) constitutes another 6-7 vol.-%. The gasoline contains most of the isohexane with some isoheptane. The light naphtha contains the balance of isohexane with the bulk of isoheptane. Presence of isohexane and isoheptane in both cuts is unavoidable. This "wild gasoline" then is depropanized, removing the C_1-C_3 fraction, followed by debutanizing and deisopentanizing in conventional equipment. Deisopentanizer bottoms form a part of the feedstock for Isohexane Op. 1. The plant flow diagram is shown in Fig. 2.

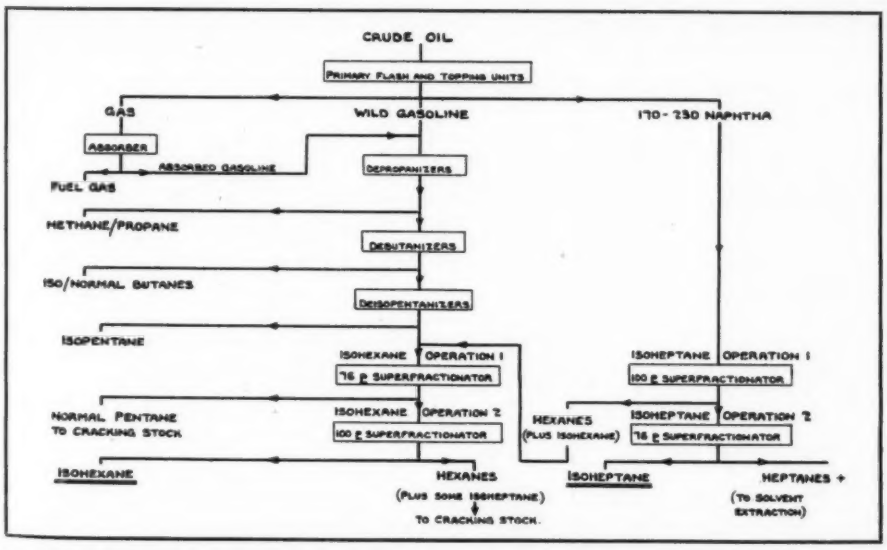

Fig. 2—Schematic diagram of refinery operation at Abadan to incorporate superfractionation of aviation gasoline base stocks

TABLE 2—Properties of Isohexane Isoheptane Fractions

	Isohexane	Isoheptane
Specific gravity at 60° F.	0.6670	0.7290
ASTM distillation, ° F.		
IBP	135.5	178.7
5% distilling to	136.4	180.5
10% distilling to	136.4	181.4
20% distilling to	137.3	182.3
30% distilling to	137.3	183.2
40% distilling to	138.2	184.1
50% distilling to	138.2	185.0
60% distilling to	139.1	185.9
70% distilling to	140.0	186.8
80% distilling to	140.0	188.6
90% distilling to	140.9	191.3
F.B.P.	143.6	213.8
Total distillate, vol., %	98	98.5
Residue, vol., %	1	1.0
Loss, vol., %	1	0.5
Sulfur, wt., %	0.0003	0.0002
Reid vapor pressure, psi	7.4	3.1
Cold test, ° F.	Below −94	Below −94
Aromatics, vol., %	0.3	4.7
First aniline point, ° F.	154.7	124.0
Second aniline point, ° F.	156.2	132.4
Octane No. (C.F.R. MM.)	79.5	74.3
Octane No. (C.F.R. MM.) +5.5 ml. TEL/IG.	103	91.9
F4 (3-C) rich mixture rating +4.8 ml. TEL/IG.:		
% S+1.25 ml. TEL/USG.	87.6	88.7
S+4 value	86	86.8
Index No.	109.4	111.5
F4 (3-C) rich mixture rating +5.5 ml. TEL/IG.:		
% S + 1.25 ml. TEL/USG.	89.4	91.2
S + 4 value	87.2	88.3
Index No.	112.6	116

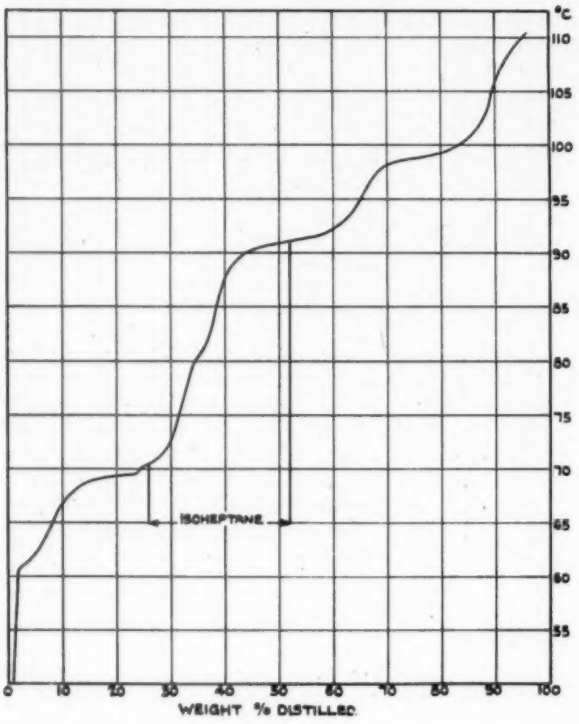

Fig. 3 — True-boiling-point distillation of feedstock for isoheptane production, first operation

Naphtha from the atmospheric column is isoheptane feedstock, a typical true-boiling-point distillation of which appears in Fig. 3. This illustration also gives the yield of isoheptane having a rich-mixture performance of 89, (S+4 scale), with 5.5 ml. TEL per Imperial gal. Overhead from superfraction of this stock, which consists largely of *n*-hexane but also has some isohexanes, is blended with the deisopentanized gasoline previously discussed to form the composite feedstock for isohexane production. A true-boiling-point curve for a typical stock is shown in Fig. 4, with a yield of isohexane having the rich mixture performance of 88, (S+4 scale), with 5.5 ml. TEL per Imperial gallon.

Superfractionation Operations

Isohexane, Op. 1—The function of this operation is to separate *n*-pentane from cyclopentane, which must be carried out in such a way that loss of the binary mixture cyclopentane-neohexane in the overhead is kept to a minimum, while the amount of undesired material in the bottoms should be such as will give a final product containing between 1-2% *n*-pentane, since this component is not too inferior a diluent and can be tolerated in small amounts.

At Abadan this operation is carried out in the 76-plate column on the feedstock whose properties are shown in Fig. 4, with a cold reflux ratio of 3.5:1. This results in the recovery of 90-95% of the cyclopentane-neohexane fraction into the bottoms product with an *n*-pentane content of 0.5%.

Isohexane, Op. 2—Bottoms from Isohexane Op. 1 is the feedstock for Op. 2, a true-boiling-point curve for which is shown in Fig. 5. Success of this operation is dependent on the production of an overhead product sustantially free of *n*-hexane. Referring to Fig. 5, it will be noted that a cut point on the true boiling point curve for this operation has been located at 65° C. (149° F.). Lowering this cut point would result in the production of a higher quality product with sacrifice of yield. Raising it would result in the inclusion of excessive quantities of *n*-hexane with a consequent rapid drop in quality out of all proportion to the slight yield increase obtained.

This cut point has been lowered in current operations in order to produce a higher quality product in reduced yield, necessitated by reduction in tetraethyl lead content at the war's end and to reduce the quantity of aromatics in the final gasoline blend. This latter was particularly desirable at Abadan in

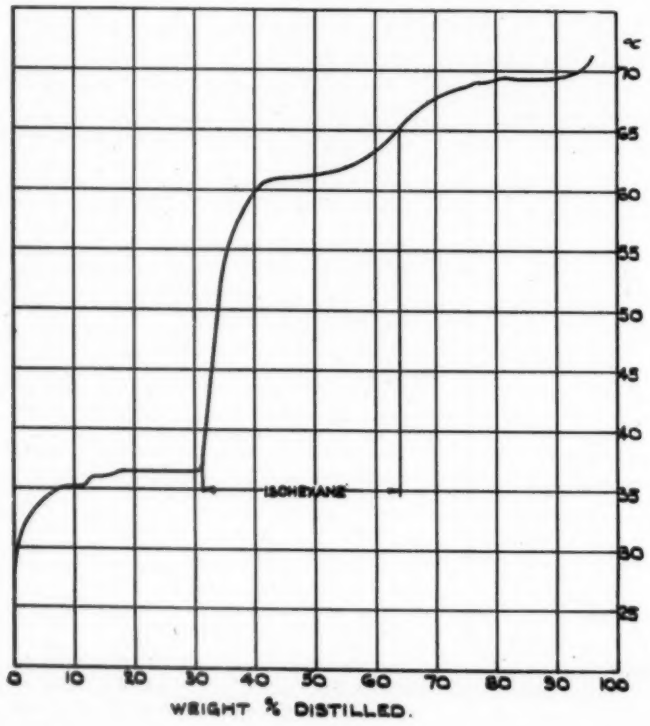

Fig. 4—(Left) Feedstock for isohexane production, Op. 1

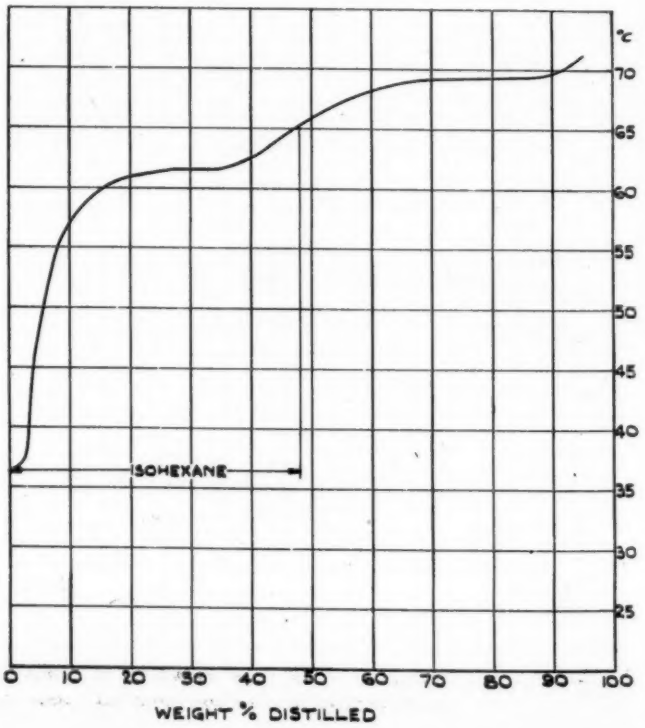

Fig. 5—(Right) Feedstock for isohexane production, Op. 2, true boiling point distillation

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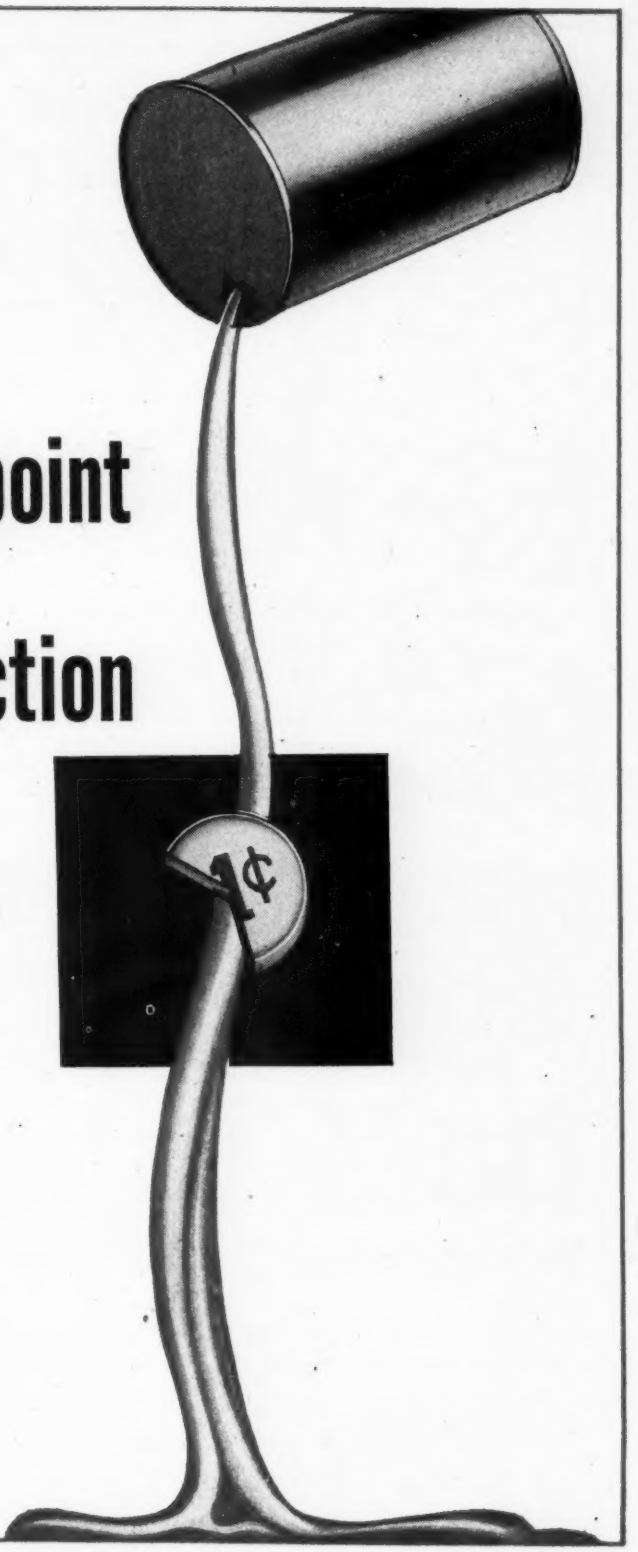

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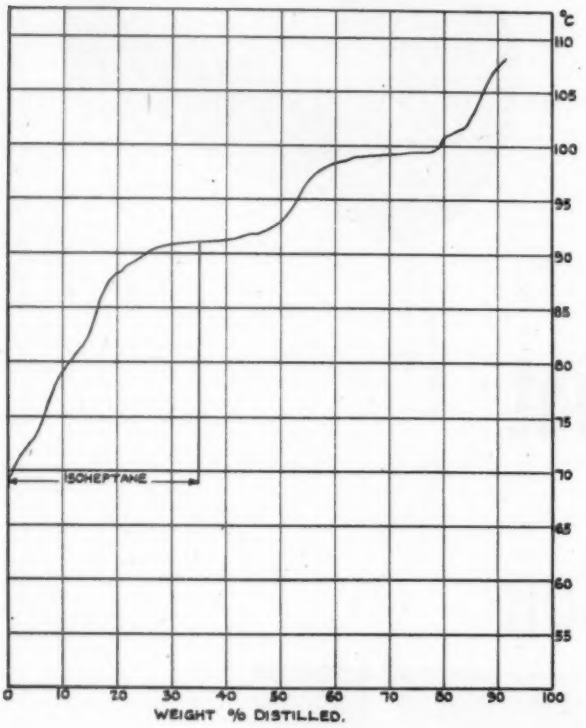
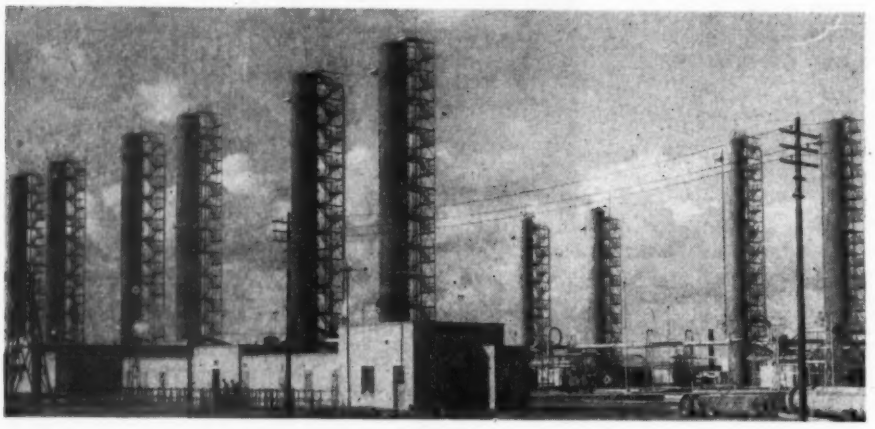


Fig. 6 — True-boiling point analysis of feedstock for isoheptane production, Op. 2



(Below) General view of superfractionation section of Abadan. Only ten of the 12 columns actually installed are visible. Each contains either 38 or 50 plates, is 120 to 140 ft. high and 12 ft. in diameter

order to reduce load on the sulfur dioxide treating plant and therby increase kerosine treating capacity.

The operation is carried out in practice on the 100-plate column with a cold reflux ratio of 7:1. The overhead product contains 1% *n*-hexane.

Isoheptane, Op. 1—In this operation as clean a cut as possible is desired between *n*-hexane and benzene-methylcyclopentane from the feedstock shown in Fig. 3. This separation is particularly difficult due to the peculiar vapor-liquid relationship existing between the system: *n*-hexene-methylcyclopentane-benzene. Success of the operation is measured by recovery of methylcyclopentane in the bottoms product, so long as this is accompanied by an amount of *n*-hexane not exceeding 4% based on the final product. To avoid running at excessive reflux ratios, the column installed has 100 plates and operates with a cold reflux ratio of 6:1, resulting in the recovery of approximately 85% of methylcyclopentane and including about 1% *n*-hexane.

Isoheptane, Op. 2—A typical true boiling point curve of the feedstock for this operation is shown in Fig. 6, from which it is desired to produce an overhead product containing a minimum of material boiling above 95° C. (203° F.) *n*-heptane. A cut point is shown at 92° C. (195.8° F.) below which, as was the case with isohexane, a higher-quality product would result with coincident drop in yield, and above which would produce an increased quantity of poorer quality material. Again, this cut-point has been lowered since the war to produce a higher-quality stock and reduce quantity of aromatics required in blending, for the same reasons given previously. However, since the cut-point is located on a plateau, and increased yield of only a slightly lower-quality product could be achieved before approaching the boiling point of pure *n*-heptane at 98° C. (208.4° F.). The operation thus is simpler than for Isohexane Op. 2.

In Abadan a 76-plate column is used for this separation with a cold reflux ratio of 3.5:1, producing an overhead product containing 1-2% of material boiling above 203° F.

Plant Control

The usual control method—temperature at some point in the tower controlling reflux rate—is not a practical one for superfractionators, where temperature differences between products are small. Hence at Abadan only one of the four superfractionation operations—removal of *n*-pentane overhead in Isohexane Op. 1—is controlled by temperature. The rest operate on volume control. With volume control, the quantity of one of the product streams withdrawn from the column is a fixed proportion of the feed, the actual quantity being determined by a true-boiling-point analy-

TABLE 3—Instrumentation—Isohexane and Isoheptane Production

	Isohexane, Op. 1.	Isohexane, Op. 2.	Isoheptane, Op. 1.	Isoheptane, Op. 2.
Flows:				
Feed	F.R.C.	F.R.C.	F.R.C.	F.R.C.
Overhead	L.C.C. with F.M.	F.R.C.	F.R.C.	F.R.C.
Bottoms	L.L.C. sets F.R.C.	L.L.C. sets F.R.C.	L.L.C sets F.R.C.	L.L.C. sets F.R.C.
Reflux	F.R.C.	L.L.C. with F.M.	L.L.C. with F.M.	L.L.C. with F.M.
Transfer	L.L.C. sets I.F.C.	L.L.C. sets I.F.C.	L.L.C. sets I.F.C.	L.L.C. sets I.F.C.
Steam to reboilers	I.T.C. (plate 13) with F.M.	F.R.C.	F.R.C.	F.R.C.
Water to condenser	F.R.C.	F.R.C.	F.R.C.	F.R.C.
Temperatures:				
Feed	I.T.C.	I.T.C.	I.T.C.	I.T.C.
Product	.....	I.T.C.	I.T.C.	I.T.C.
Pressures:				
Column	I.P.C., plate 10 to vent.	Nil	Nil	Nil
Levels:				
Condenser, water interface	L.L.C.	L.L.C.	L.L.C.	L.L.C.

Key

F.R.C.—Flow recorder controller.
L.L.C.—Liquid level controller.
F.M.—Flow meter.
I.F.C.—Indicating flow controller.
I.T.C.—Indicating temperature controller.
I.P.C.—Indicating pressure controller.

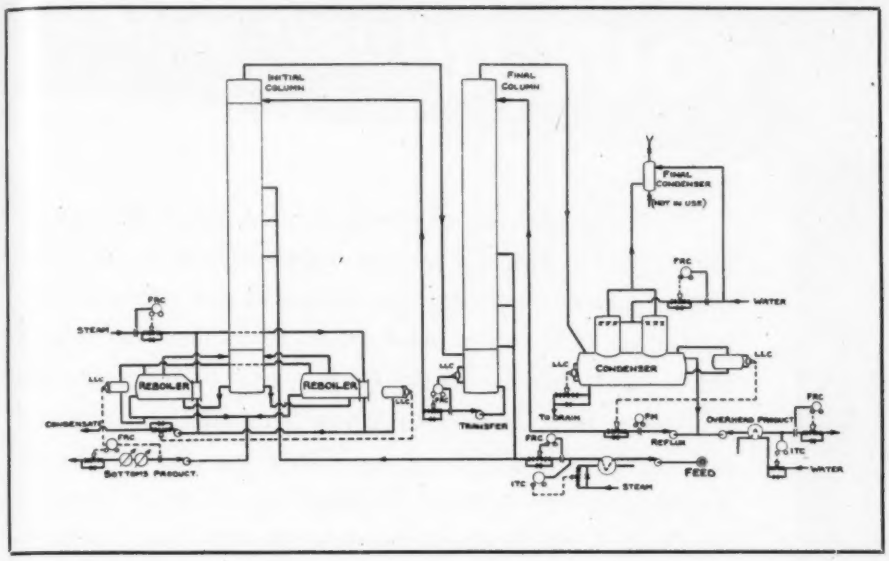
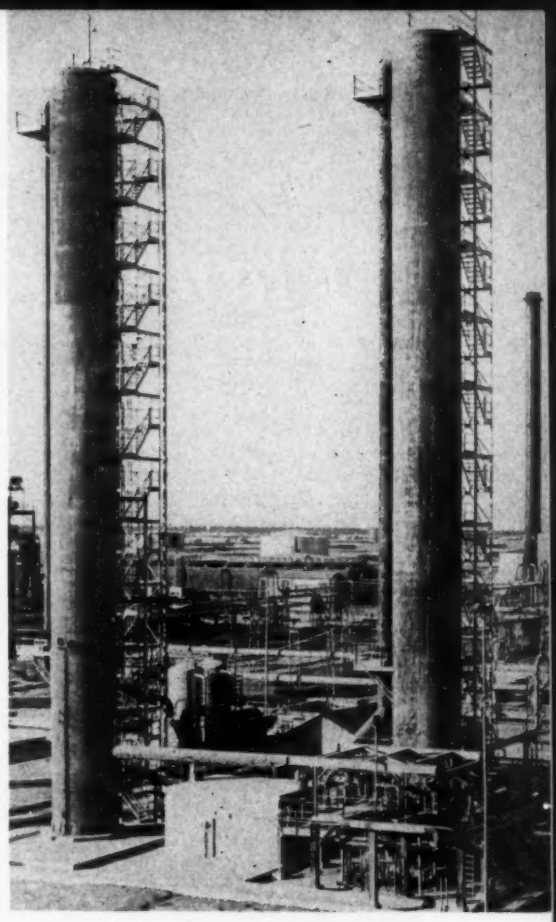


Fig. 7—Flowsheet and instrumentation for production of isohexane, Op. 2; isoheptane, Op. 1; and isoheptane, Op. 2, using volume control methods for product quality. Flow diagram for isohexane, Op. 1, is identical except that it employs temperature control for product quality. Symbols for various instruments are given in Table 3

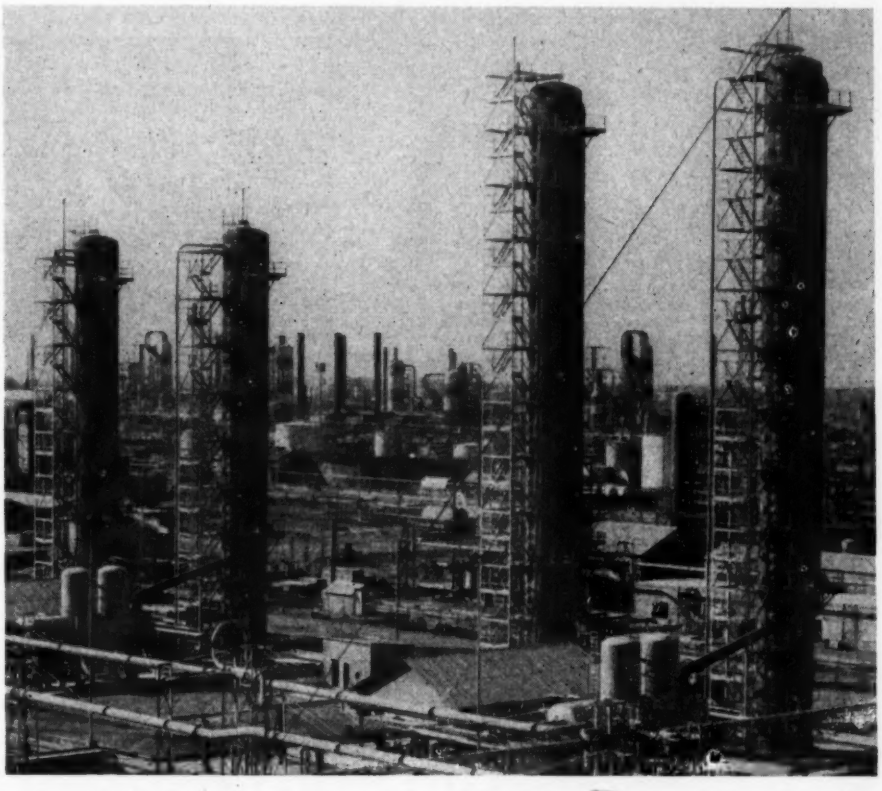


Two 50-plate columns used in initial separation of isoheptane. Tower at left recovers isoheptane (cyclopentane-neohexane mixture) as bottoms and that at right rejects n-hexane overhead. Bottoms then are processed to separate n-heptane from the isoheptane cut

sis of this stock. The other product then is withdrawn at a rate just sufficiently high enough to prevent accumulation within the tower. This requires a fairly constant feedstock composition and metering errors must be eliminated. (i. e., the metering error, if any must be constant; absolute flow measurements are not necessary.) For this reason, Abadan's fractionators operating on volume control (Fig. 7) have steam preheaters on the feed stream to minimize metering errors by maintaining a constant feed temperature.

Originally it was intended to operate all superfractionators by volume control. However, in the case of Isohexane Op. 1, inspection of the true-boiling-point curve of Fig. 3 shows a well-accentuated break between *n*-pentane (b. p. 36° C.) and cyclopentane (b. p. 49° C.), leading to the conclusion that temperature control probably would be most satisfactory. In actual operation it later was found that considerable "layering" could be encountered in the feedstock due to unavoidable fluctuations in both quality and quantity of the deisopentanized gasoline and overhead from Isoheptane Op. 1, both passing to isohexane base storage. This would result in so many complications as to make volume control unfeasible.

Instrumentation and flows are shown for the other three superfractionation operations in Fig. 7. The only difference between flows in this illustration and that for Isohexane Op. 1 (not shown)—is the modification for temperature instead of volume control. It will be noted that jet condensers are used instead of the tubular exchangers conventional in the U. S. Due to climatic conditions in Abadan, high cooling water temperatures are a problem. Direct contact with water improves the heat transfer efficiency by elimination of the tubular surface. Moreover, the jet condensers have a greater capacity, size for size, than the tubular type and also require less maintenance. These jet



View of two superfractionation units at the Abadan, Iran, refinery of Anglo-Iranian Oil Co., Ltd. Unit at left cuts n-pentane overhead from a cyclopentane-neohexane fraction, while that at right takes isohexane overhead from n-hexane

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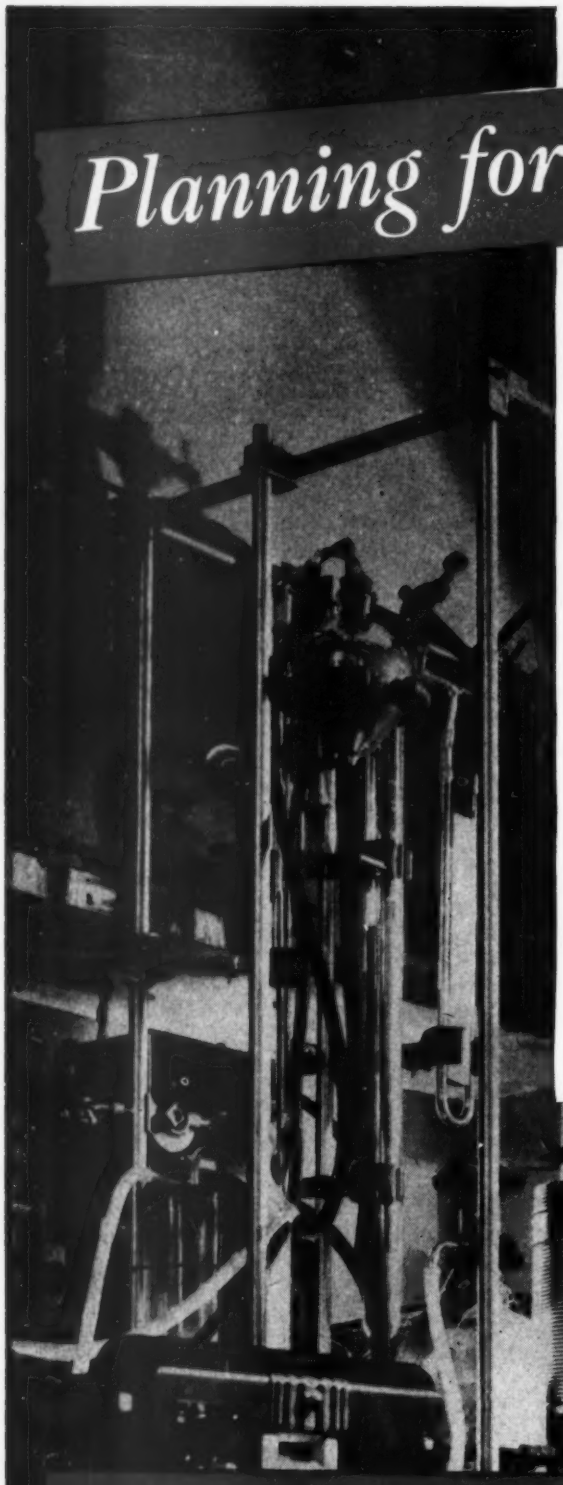

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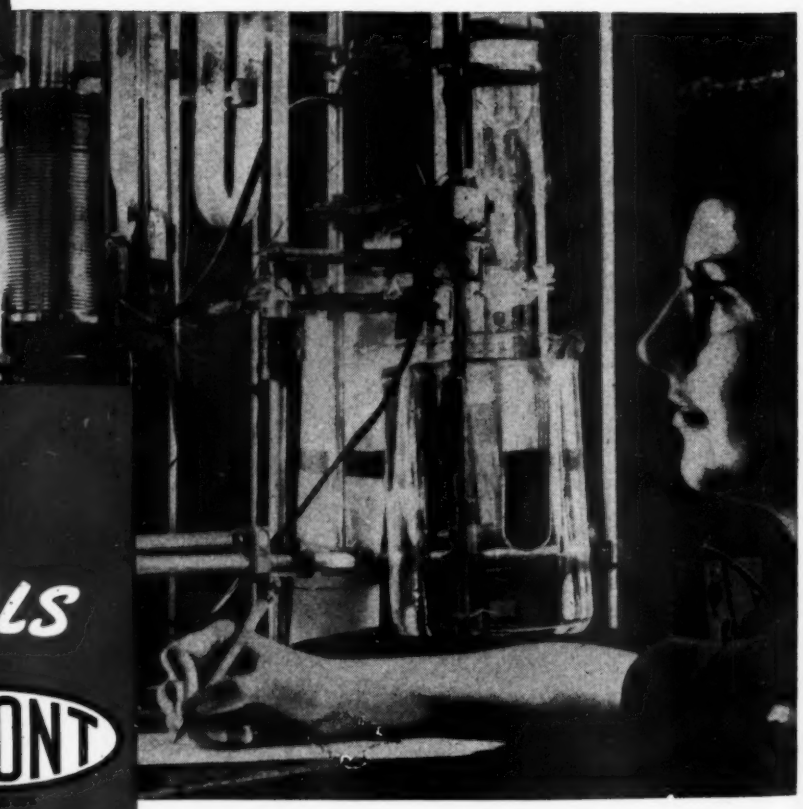

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condensers are also a feature of the crude distillation units at Abadan.

For convenience a list of control instruments used appears in Table 3, and actual operating conditions of the columns are given in Table 4.

Since three of the four operations employ volume control, great care is required in providing suitable tankage: (1) capacity must be sufficient to permit determination of a true-boiling-point analysis on tank contents, where this is required prior to feeding the unit and (2) tanks should be top-filling and bottom-emptying to minimize effects of "layering." Due to the wide fluctuation in atmospheric temperature from day to night, such tankage is of the floating-roof type to preclude losses of volatile material by tank "breathing." This also is a feature of all volatile-product storage at Abadan.

Feedstock for Isohexane Op. 1 is drawn alternately from two 71,500-bbl. tanks. In this case it is not necessary to analyze contents once a steady operation has been attained, since initial superfractionation is temperature controlled. Bottoms from this operation pass into one of two similar tanks, contents of which are analyzed since volume control is used in the second operation.

Feedstock for Isoheptane Op. 1 is taken from one of three 71,500-bbl. tanks operating in sequence; contents are analyzed because it is essential to determine the percentage overhead to be taken from the column. Experience has shown that as long as naphtha feed is fairly constant in quality it is unnecessary to analyze bottoms from Isoheptane Op. 1 before proceeding with the second operation. However, adequate storage is provided to prevent a temporary upset in the first unit from being passed on to the second, and to avoid loss of product in event one of the units is temporarily shut down.

Routine control tests consist of two distinct types: (1) true-boiling-point determinations of Isohexane Op. 2 feed and Isoheptane Op. 1 feed (occasionally also for Isohexane Op. 1 feed, and (2) distillation of column-samples.

Two types of fractionation equipment are required for the routine distillation of column samples, a 40-plate batch still and a 25-plate batch still having the specifications set forth in Table 5.

TABLE 5 — Laboratory Distillation Equipment Used for Plant Control

	40-plate Batch Still	25-plate Batch Still
Normal charge, ml.	2000	100
Theoretical plates	40	25
Static holdup, ml.	1	1.1
Total holdup at operating boilup rate, ml.	56	7.4
Operating boilup rate, ml.	1800	400
Holdup factor	2.7	2.6
Charge, holdup ratio	36 to 1	13 to 1
Packing, 40-plate Batch Still	Fenske type single turn glass helices I.D. of 0.125 in. Wire diam. 0.02 in.	
Packing, 25-plate Batch still	Spiral screen used by Leckey & Ewell, *Ind. Eng. Chem.*, 12, 544, (1940)	

Isohexane, Op. 1 — This operation makes a split between *n*-pentane and cyclopentane. To determine *n*-pentane in the bottoms product a 2-liter sample is charged to the 40-plate still. The percentage distilling to 43° C. (109.4° F.) is reported as *n*-pentane when a reflux ratio of 40:1 is used. This test is made every 24 hours when steady operation is reached; when starting up it should be made every four hours.

Determination of cyclopentane-neohexane leaving with the overhead is made on the 25-plate still with a sample of 100 ml. The first 70% is distilled over at 20:1 reflux ratio and discarded. The fraction distilling at 40:1 reflux ratio between 80% over and the minimum possible residue (about 10%) is collected. Residue is distilled to dryness to remove traces of grease, so that the final distillate contains only *n*-pentane, cyclopentane and neohexane. The refractive index of the 80-90% distillate and redistilled residue are determined and the analysis calculated from a knowledge of the refractive indices of the components by direct proportion, using values of 1.3931 for the cyclopentane-neohexane component and 1.3576 for *n*-pentane.

As previously stated, this test should be made frequently during start-up, but once weekly will suffice when steady operation is attained since, with substantially-constant feedstock composition

TABLE 4—Actual Plant Operating Conditions—Production of Isohexane and Isoheptane

	Isohexane production		Isoheptane production	
	Op. 1.	Op. 2.	Op. 1.	Op. 2.
Quantities:*				
Feed, gal./hr.	20,800	10,900	21,000	22,800
Overhead, gal./hr.	7,960	4,950	6,850	6,650
Bottoms, gal./hr.	12,840	5,950	14,150	16,150
Reflux, gal./hr.	31,800	35,800	40,400	29,000
Total overhead, gal./hr.	39,760	40,750	47,250	35,650
Transfer, gal./hr.	59,400	38,200	72,000	47,800
Steam, lb./hr.	45,850	43,900	61,300	60,000
Water, gal./hr.	47,800	56,600	71,000	65,500
Temperatures, ° F.:				
Feed preheater:				
Feed to preheater	109	108	106	107
Feed from preheater	130	138	134	132
Column:				
Vapor to condenser	152	140	150	182
Vapor above plate 53 or 69	(53)160	(69)165	(69)179	(53)212
Vapor above plate 47 or 61	(47)162	(61)164	(61)183	(47)218
Vapor above plate 39 or 51	(39)174	(51)171	(51)197	(39)226
Vapor from initial column	180	175	201	230
Vapor above plate 25 or 34	(25)...	(34)180	(34)214	(25)248
Vapor above plate 13 or 16	(13)190	(16)190	(16)244	(13)259
Vapor above plate 1	222	198	247	...
Liquid from plate 1	223	198	248	...
Reboilers:				
Vapor from reboiler 1	225	202	254	276
Vapor from reboiler 2	225	200	254	276
Liquid to reboiler 1	...	...	248	...
Liquid to reboiler 2	...	...	248	...
Liquid from reboilers 1 and 2	226	202	256	278
Reflux:				
Reflux to final column	129	120	126	123
Transfer to initial column	178	171	199	226
Condenser:				
Condensate to overhead cooler	125	121	126.5	125
Water to condenser	71	68.5	77	76
Water from condenser	126	118	130	121
Overhead cooler:				
Overhead from cooler	100	105	105	108
Water from cooler	...	106	106	...
Bottoms cooler:				
Bottoms to cooler	...	...	256	274
Bottoms from cooler	76	71	206	79
Water from cooler	...	73	119	...
Pressures, psig:				
Column top	28	2	2	1
Final column base	...	7.5	10.5	6.5
Initial column top	...	7.5	13	8.5
Initial column base	32.5	13.5	24	20
Steam:				
Main steam, psig	216	211	214	218
Main steam, ° F.	...	...	442	445
Steam to reboilers, psig	20	...	83	70
Condensate from reboiler, psig	...	...	35	...
Condensate from reboiler 1, ° F.	...	...	276	...
Condensate from reboiler 2, ° F.	...	...	264	...
Position of feed point, plate no.	39	51	51	15
Reflux to top tray, lb./hr.	199,800	240,000	273,000	211,800
Reflux from top tray, lb./hr.	217,000	255,000	298,000	255,500
Vapor velocity below top tray, ft./sec.	1.4	3.2	4.7	3.3
Heat input to reboilers, MBtu/hr.	45.8	46.4	60.1	55.6
Heat input to preheaters MBtu/hr.	1.5	1.7	2.2	2.0

* British Imperial gal.=0.028594 American bbl., 1.20094 American

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and operating at a given reflux ratio, the recovery of cyclopentane-neohexane will remain constant.

Isohexane, Op. 2—The bottoms product from Op. 1 is allowed to accumulate in a 71,500-bbl. tank. From a true-boiling-point analysis of the stock and using experimentally determined rich-mixture blending factors, the exact location of the cut-point is fixed for a given-quality product. The unit is set to give the calculated percentage overhead and a daily octane number is a sufficient check for plant operation.

Isopentane, Op. 1—This column removes *n*-hexane overhead with a minimum quantity of the benzene-methylcyclopentane binary. The quantity of *n*-hexane in the final product is limited by the octane quality desired. Two liters of bottoms sample is charged to the 40-plate still and the column allowed to reach eqilibrium under total reflux. Column head temperature is recorded after 30 to 45 minutes. Experience has shown that if this temperature is 70° C. (158° F.), the final product will be satisfactory; if as low as 69° C. (156.2° F.) the *n*-hexane content of the final product will exceed that permissible in the specification (4% by volume), and if 71° C. (159.8° F.) an excessive loss of benzene-methycyclopropane is occurring in the overhead.

This test is made every eight hours and in spite of its empirical nature, has been found completely satisfactory. Dependent on the temperature registered, an alteration is then made on the overhead flow meter on the unit, a figure of 71° C. indicating a reduction in the overhead withdrawal of 1 to 1.5% based on feed. The unit is initially set by the true-boiling-point analysis of the feed, but final adjustments always are made from this test.

Isoheptane, Op. 2—Purely on the basis of experience and from the true-boiling-point distillation of the feedstock to Isoheptane Op. 1, gravity determinations on the overhead every four to eight hours will suffice to assure a constant-gravity product. Otherwise, a true-boiling-point analysis of the overhead is required.

It is pointed out that this overhead, which is required by specification to contain a minimum quantity of material boiling over 95° C. (203° F.), can be alternatively determined by ultraviolet spectroscope because the material contains a small quantity of toluene. The ratio of toluene concentration to the non-aromatic portion of the above-95° C. fraction shows little variation and hence can be quickly determined with the instrument.

Similarly, in Isohexane Op. 2, the *n*-hexane removed always contains a small quantity of benzene because of the peculiar vapor-liquid relationship between the two compounds. Ultraviolet spectroscopic determination of the aromatic content of the sample thus will provide a quick control test.

BUBBLE PLATE COLUMN DESIGN

By ROBERT R. WHITE

Associate Professor
Department of Chemical and
Metallurgical Engineering
University of Michigan

Earlier articles in this series have covered the methods for calculating process variables in fractional distillation. This month the author progresses to some of the factors involved in the actual physical design of bubble plate columns, in which a primary consideration, he points out, is the provision of sufficient capacity for both liquid and vapor streams. Discussed are overall plate efficiencies, column diameter, vapor lines, liquid capacity, liquid height in downspouts, weirs, and liquid level on plates.

THE physical design and lay-out of fractionating equipment is dependent largely on the judgment of the engineer. The previous discussions have been concerned primarily with the calculation of process variables such as temperatures, pressures, reflux ratio, and the number of equilibrium trays required for separating binary mixtures. Such basic information, necessary for design, is subject to more or less exact calculation.

While these calculations are important, the proper design of fractionating equipment is even more important although more difficult. An error in estimating the number of plates is usually not nearly so serious as an error of equivalent magnitude in estimating tower diameter or downspout capacity, for once the tower is erected these latter items cannot be changed, whereas an error in the number of plates can usually be compensated for by an adjustment of operating conditions.

A primary consideration in column design is the provision of sufficient capacity for both the liquid and vapor streams. Present information[3, 9, 13] on plate efficiency indicates that, where ample fluid handling capacity is provided, in most cases the plate efficiency is not sensitive to minor variations in standard tray lay-outs.

Overall Plate Efficiency

The overall plate efficiency is defined as the number of equilibrium stages required for a given separation divided by the number of actual plates required. While this factor leaves much to be desired from a theoretical point of view, it has proven to be a convenient, and in most cases a reliable method of correlating practical operating results. Other definitions of plate efficiency based on mass transfer theory have been used[14], but at the present time, while considerable progress has been made[10, 22], theoretical methods have not yet reached the point of development where they can be used to predict plate efficiency either conveniently or with confidence.

Since overall efficiencies are based upon performance data, the values reported include not only the effect of the failure of the actual plates to produce equilibrium between the contacted phases but also may reflect inaccuracy in obtaining the data as well as errors or approximations in the method of calculating the number of equilibrium plates required. As pointed out by Kirkbride[13], it is important when using overall plate efficiencies reported in the literature, to understand the methods of calculation used so that proper allowance for differences in the methods of calculation can be made. This is particularly important when dealing with multicomponent mixtures because of the wide usage of approximate methods of calculation.

A recent correlation[16] of overall plate efficiencies, shown in Fig. 1, presents plate efficiency as a function of relative volatilities of the key components and the molal feed viscosity. The molal feed viscosity is the sum of the products of mol fraction and viscosity for each component of the feed taken at the arithmetic average of the top and bottom temperature of the column. While this correlation was developed primarily from data on petroleum hydrocarbon fractionating units, data from the fractionation of alcohol and water, and other organic liquids also correlate according to Fig. 1, although in some instances the values given by the figure appear to be somewhat low.

Rough figures obtained from the literature[2, 12, 15] indicate that light hydrocarbon columns operate at about 100% efficiency, low pressure hydrocarbon absorbers at about 20 to 45% efficiency, high pressure absorbers (from 100 to 600 psi) at about 45 to 65% efficiency and alcohol-water columns at 70 to 100% efficiency. Fig. 1 also correlates the results from commercial sieve plate columns fractionating acetic acid-water mixtures, beer, and alcohol-water mixtures.

In general all of the above values reported have been obtained from both large and small columns which have been operated satisfactorily under so-called normal operating capacities. The exact description of what are normal operating conditions is subject to wide variation and therefore these values must be used with caution according to the judgment and the experience of the engineer.

Column Diameter

The efficiency of the agitation or contacting between the liquid and vapor on a bubble cap plate depends largely on the energy supplied by the vapor in passing through the liquid on the plate. At very low vapor velocities, low plate efficiencies are obtained, probably because of a decreased liquid level on the plates (a greater proportion of liquid passing down through the drain holes), the channeling of the vapors due to slight differences in liquid head at different points on the plates, and the formation of relatively large bubbles of vapor. Higher vapor velocities produce higher plate efficiencies because of

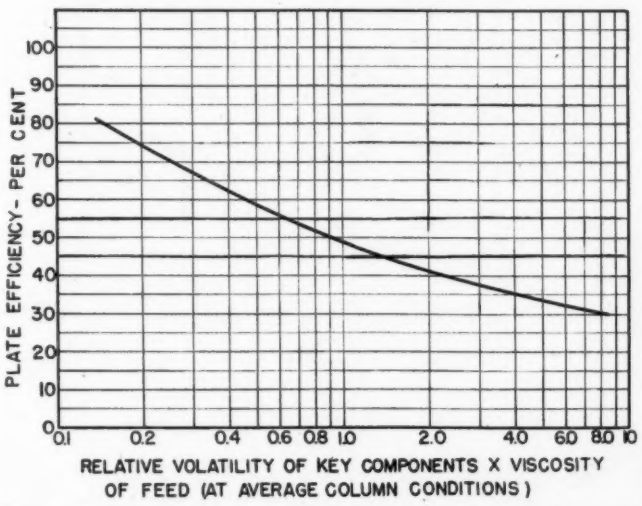
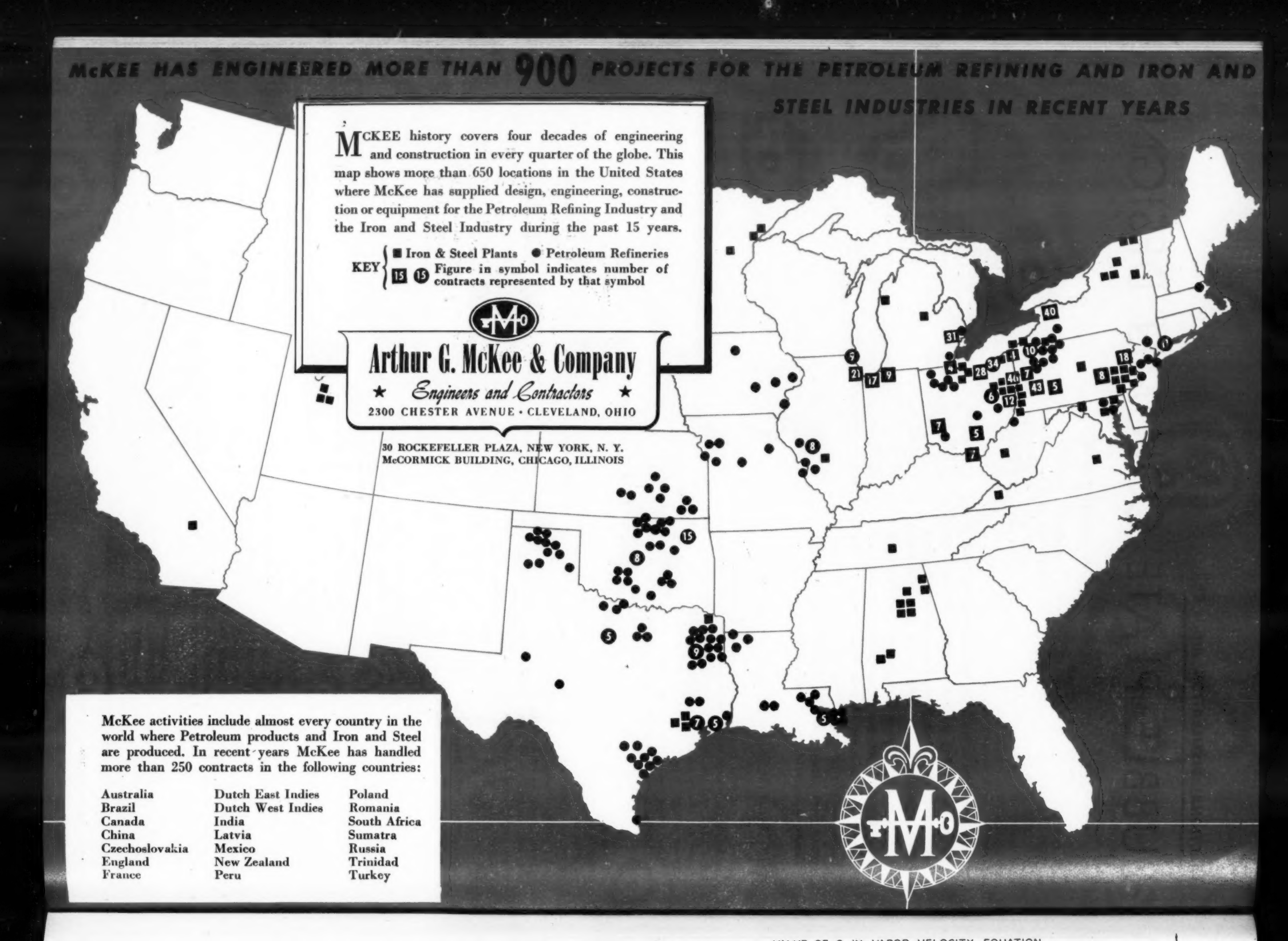


Fig. 1—Plate efficiency as a function of Molal Feed Viscosity and relative volatilities of key components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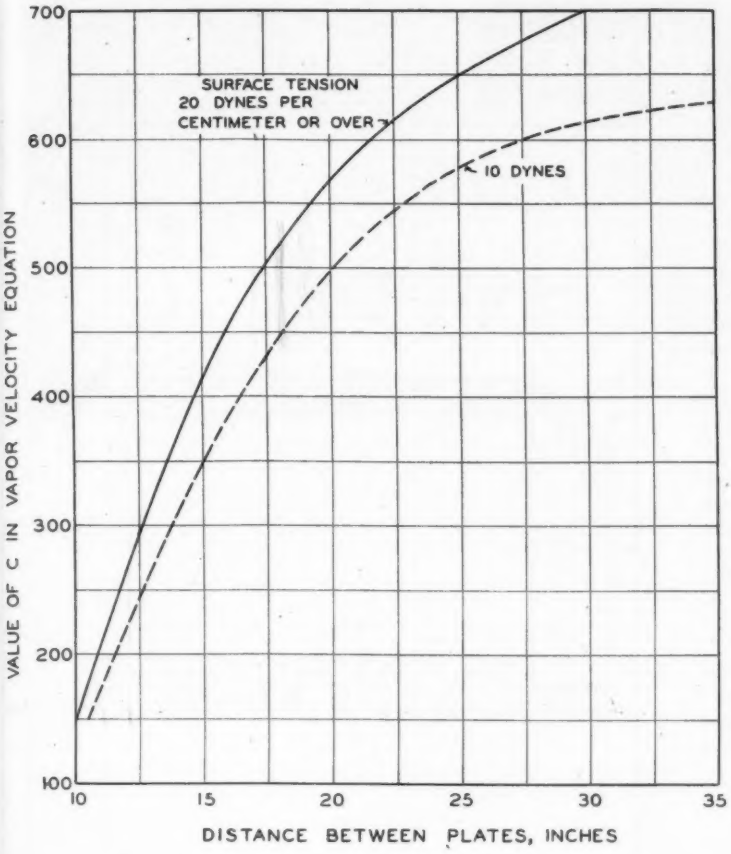

Fig. 2—(Left) Values of Parameter, C, as a function of plate spacing and surface tension

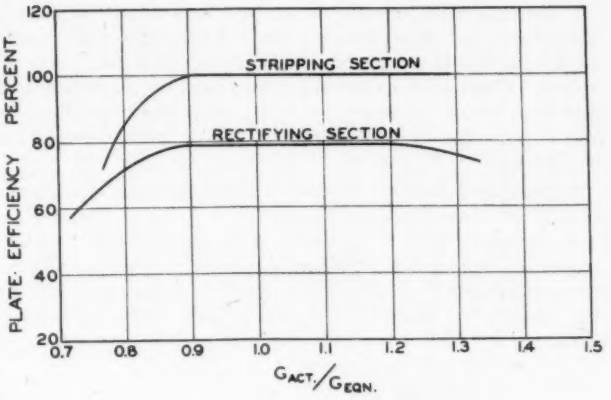

Fig. 3—(Above) Plate efficiencies obtained in several columns, plotted as a function of actual vapor load relative to calculated vapor load

thorough contacting on the liquid and vapor. At very high vapor velocities, entrainment of liquid by the vapor begins and the vapor tends to "cone" the liquid away from the slots of the bubble caps[17], by-passing the liquid on the plates and producing low plate efficiencies.

Investigations of the effect of vapor velocity on plate efficiency[3] have shown that maximum plate efficiency was obtained at vapor velocities calculated by Equation 1.

$$G = C\sqrt{\rho_v(\rho_L - \rho_G)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

G = mass velocity of the vapor, lbs. per hr. per sq. ft. of column cross-section,

C = parameter depending upon the plate spacing and the surface tension of the liquid on the plate,

ρ_L, ρ_G = densities of the liquid and vapor, respectively, at the column conditions, lbs. per cu. ft.

The values of the parameter, C, may be determined from Fig. 2, which plots the value of C as a function of plate spacing and surface tension[4]. Table 1 lists the surface tension of a number of typical liquids at representative temperatures. Thus, a suitable column diameter may be determined by determining the point of maximum vapor load in the column, as lbs. per hr. The mass velocity per sq. ft. of column area at which the plates will operate most efficiently may be computed from Equation 1. The quotient of these figures is the total cross-sectional column area which should be used. In making this calculation it is necessary to assume arbitrarily a plate spacing. Subsequent calculations for liquid capacity determines whether or not this assumed plate spacing is satisfactory.

Fig. 3 shows the plate efficiencies obtained in several columns as a function of vapor load relative to that calculated from Equation 1 and shows that the plate efficiency is relatively insensitive to vapor load over a wide range with properly designed plates[3]. Thus, column diameters determined by the above procedure provide ample overload capacity so far as efficiency is concerned, since the vapor velocities calculated from Equation 1 can be exceeded without a serious decrease in plate efficiency.

In rare cases the vapor load in different parts of a column will differ so markedly that a column constructed of sections having different cross-section area may be justified. Usually such construction is too expensive to justify the slight improvement in fractionating performance obtained, as indicated by Fig. 3.

Equation 1 was originated[4, 5] to compute the vapor velocities at which entrainment is negligible, and is a modification of Stoke's law. Entrainment is the mechanical transport of liquid from one plate to the plate above by vapor and may be expressed quantitatively as pounds of liquid per pound of dry vapor. The partial recirculation of liquid between two plates so obtained reduces the fractionation and decreases plate efficiency.

TABLE 1—Surface Tension of Common Liquids*

Material	Temperature ° C.	Surface Tension Dynes/cm
Methanol	40	20.9
Methanol	100	15.7
Ethanol	60	19.0
Ethanol	100	15.5
n-Propyl alcohol	80	18.8
i-Propyl alcohol	80	17.0
n-Butyl alcohol	130	15.1
i-Butyl alcohol	130	13.7
Benzene	60	23.7
Benzene	100	18.8
Toluene	100	19.4
Phenol	180	23.6
Aniline	150	27.9
Acetone	80	16.2
Acetic acid	100	19.8
Furfural	160	25.4
Carbon tetrachloride	100	17.3
Hopentane	100	17.7
n-Octane	60	17.9
Decane	160	10.7
Water	60	66.2
Water	100	58.9

* At their respective boiling points.

Entrainment apparently is of two types: (1) splashing of liquid from one plate into the risers of the plate above and (2) the suspension of a mist of small droplets of liquid in the vapor stream. Ordinarily splashing entrainment is important only at very high vapor velocities and with small plate spacings. Equation 1 gives the vapor velocity at which "mist" entrainment is negligible.

Entrainment and its effect on plate efficiency has been the subject of considerable research[1, 4, 7, 8, 11, 19, 20] but variations in plate efficiency observed in commercial installations cannot be explained entirely on the basis of entrainment. In one case, entrainment of 0.4 lbs. of liquid per pound of dry vapor was observed. Theoreticaly, this should have reduced plate efficiency by 25%. Actually the plate efficiency was reduced two or three times this amount.

It is now believed that basic changes in the type of contact between the liquid and vapor on the plates such as "coning" occur long before entrainment seriously affects plate efficiency and that the most important effect of entrainment is an increase in the liquid loads carried by the downspouts. However, where rigid specifications with respect to color or impurities must be met by distillate products, small amounts of entrainment may be very serious entirely apart from considerations of plate efficiency or capacity.

Vapor Lines

The vapor lines from the top of a column must be sufficiently large to permit passage of the vapors without excessive pressure drop. The pressure drop may be calculated by well-known methods. The following figures represent usual commercial practice[18]:

Operating Pressure	Vapor Velocity, ft./sec.
Atmospheric	40- 60
100-50 mm Hg	100-150
below 50 mm Hg	150-200

Liquid Capacity

The first observable effect of exceeding the liquid capacity of a column is an increase in the quantity of liquid on the trays and in the downspouts. This is the first step in the approach to a condition known as flooding, in which large quantities of liquid accumulate on the trays and in the downspouts. If this condition becomes acute, as is almost always the case once it has started, the liquid backs up in the column and is carried out through the top with the vapor. This action is called "puking."

A column operating normally is illustrated diagrammatically in Fig. 4. In order that the vapor from plate 2 may pass through the bubble caps and liquid on plate 1, there must be a pressure differential $P_2 - P_1$. Further, in order that the liquid on plate 1 may pass through the downspout to plate 2, there must be a liquid head in the downspout above the liquid on plate 2, sufficient to balance the pressure differential producing the vapor flow and in addition to produce liquid flow through the downspout.

When the downspout becomes filled with liquid any slight increase in the liquid or vapor flow will increase the liquid level on the plate. The increase in liquid level on the plate increases the pressure differential across the plate which, in turn, will cause more liquid to back up through the downspout, producing a further increase in the liquid level on the plate. The result of this accumulative cycle is that the column fills with liquid and ceases to function as a fractionating unit. This phenomenon is called "flooding."

When the column becomes filled with liquid as a result of flooding, the pressure differentials between the plates disappear to a large extent, while the pressure in the still or reboiler will continue to increase if the temperature of the heating fluid is sufficiently high. Eventually this pressure will become great enough to blow liquid over the top of the column through the vapor lines in more or less violent spasms. This is known as priming or puking. During such periods vapor generated in the still bubbles through the column of liquid in the column intermittently. While vapor is being generated no liquid flows to the still or reboiler. When vaporization ceases due to the increase in pressure, liquid flows to the still. It is easy to understand why a flooded or partially flooded column cannot fractionate efficiently under such conditions and it is essential that the plates of a column be spaced at a sufficient distance that flooding will not occur under the normal variations in operating conditions.

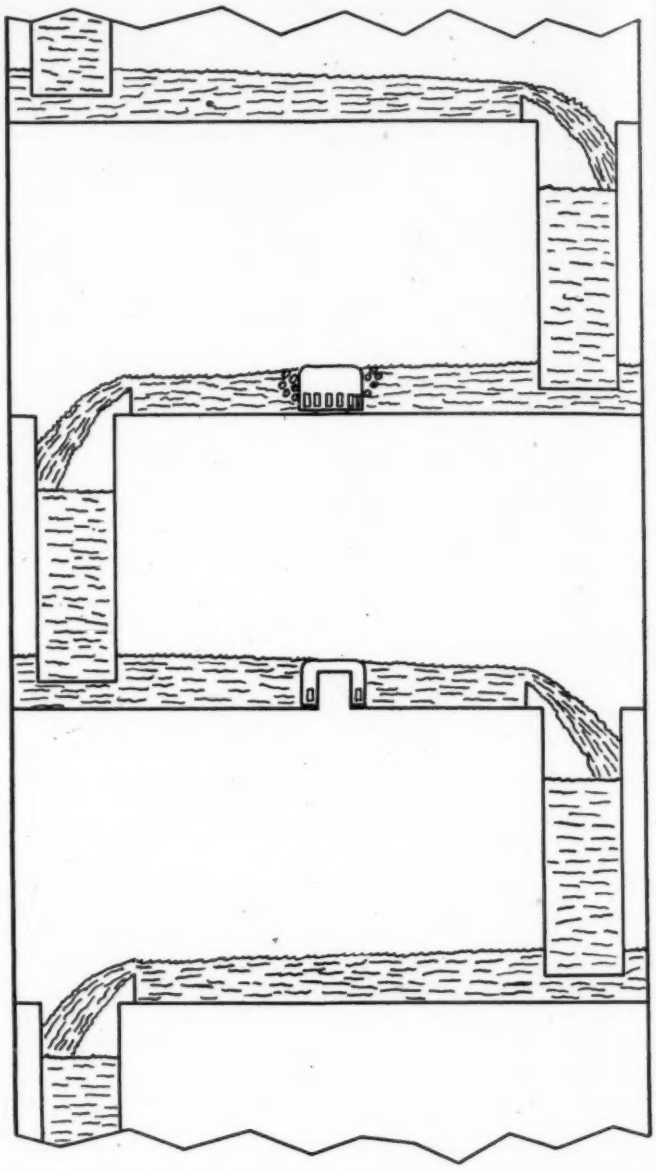

Fig. 4—Sectional view of a bubble plate column operating normally

Where frothy liquids are involved this effect is much more serious and the flooding occurs much more rapidly. When the free surface of the liquid in the downspouts is well below the entrance there is sufficient surface along the walls of the downspout and over the weir for the entrained vapor to disengage from the liquid and the downspout will operate properly. As the liquid flow increases, and the downspout begins to fill with liquid, this surface is decreased and the point may be reached at which the vapor can no longer disengage from the liquid, thus passing down through the downspout with the liquid. Since the density of the mixture of liquid and vapor is much less than that of the liquid alone, a much higher head of froth is required to maintain the seal between the plates than is required with liquid alone. Consequently the entire cycle de-

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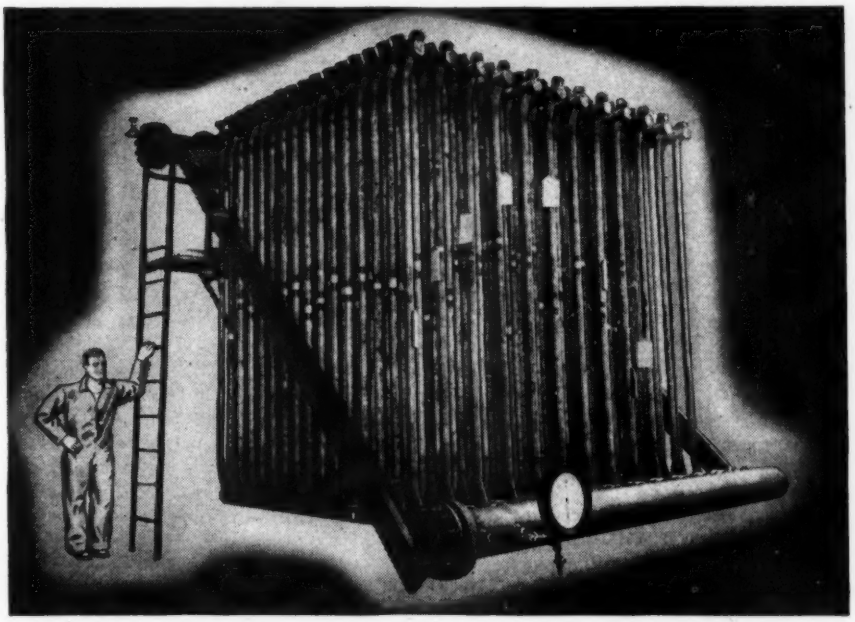

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scribed above occurs more rapidly. Thus, it is essential that ample liquid carrying capacity be provided in the column with materials that tend to froth or foam. It has been reported[17] that it is helpful to place a top baffle in front of the downspout weirs so that liquid must pass beneath this baffle before passing over the weir. This baffle should extend to the level of the slots if it does not seriously restrict liquid flow. Ample disengaging space for the vapor should be provided between the downspout weir and the entrance to the downspout as shown in Fig. 7, allowing a minimum time for vapor liberation between the last row of caps and the overflow weir of one second per foot of liquid depth on the tray[13].

Liquid Height in Downspouts

The maximum height, H_{max}, of liquid in the downspout from plate 1 above plate 2 in Fig. 4 is equal to the plate spacing plus the height of the weir on plate 1. The height, H, of the liquid in the downspout above plate 2 may be calculated from the various factors contributing to pressure differentials in the flow paths and the dimensions of the weirs according to Equation 2.

$$H = (P_2 - P_1) + h_1 + h_w + h_{ow} + h_p \quad \ldots\ldots\ldots (2)$$

where

H = height of liquid in downspout above the plate, inches of liquid flowing,
P_1, P_2 = pressure above plates 1 and 2, inches of liquid flowing,
h_p = friction head loss due to liquid flow in downspout, inches,
h_w = weir height, inches,
h_{ow} = head of liquid over the weir, inches,
h_p = liquid head differential producing liquid flow across the plate.

In general, a well-designed column will provide a maximum allowable height (distance between plates) equal to at least 200% of the calculated liquid height under the expected operating conditions[5, 13].

The pressure differential $(P_2 - P_1)$ under which vapor flows through plate 1 may be evaluated from the various frictional and static resistances in the path of vapor flow according to Equation 3.

$$P_2 - P_1 = h_{sv} + h_{bc} + h_{sl} + h_{vl} \quad \ldots\ldots\ldots (3)$$

where

h_{sv} = static head of vapor over the distance $H - h_w + (h_{ow} + h_p)$,
h_{bc} = friction head loss through the bubble caps,
h_{sl} = static head of liquid on plate above vapor outlet from bubble caps,
h_{vl} = friction head loss due to vapor flow through the liquid on plate.

Designating the plate spacing as $P.S.$, since

$$P.S. + h_w = 2H \quad \ldots\ldots\ldots (4)$$

in a well designed column and since h_{sl} is approximately equal to $(h_w + h_{ow} + h_p/2)$, combining Equations 2, 3 and 4

$$P.S. = 2\,[h_{sv} + h_{bc} + h_{vl} + 2h_{ow} + h_1 + 1.5\,(h_w + h_p)] \quad \ldots\ldots\ldots (5)$$

The term h_{vl} probably can be neglected at all times. The term h_{sv} is important only in high pressure columns, and the term h_p is usually of importance only in columns of large diameter (above 6 ft.). When these terms may be neglected

$$P.S. = 2\,[h_{bc} + h_1 + 2h_{ow} + 1.5h_w] \quad \ldots\ldots\ldots (6)$$

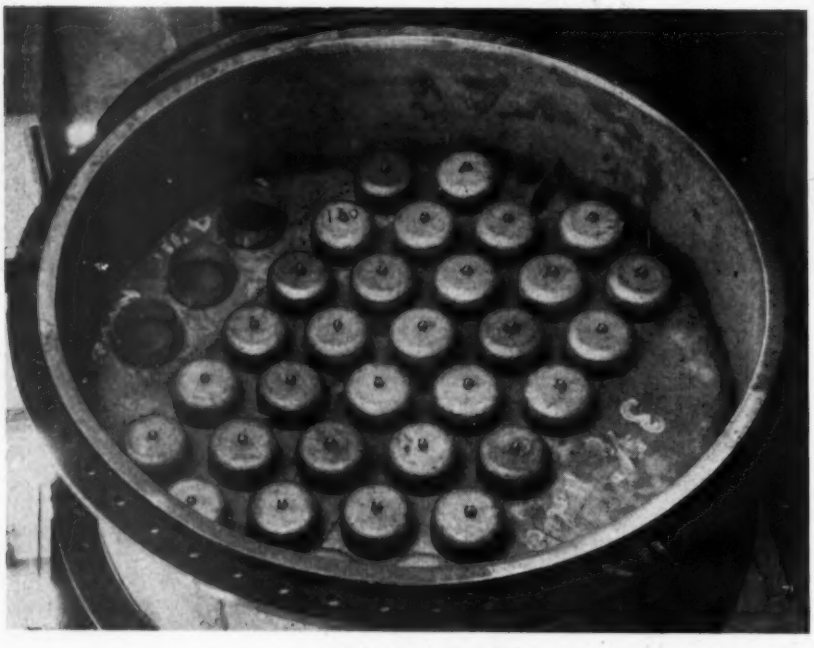
Weirs and Liquid Level on Plates

The purpose of a weir is to maintain a liquid level on the plate. The liquid level on the plate is equal to the height of the weir plus the head of liquid over the weir.

The head of liquid over the weir is directly proportional to the quantity of liquid passing over the weir and is inversely proportional to the length of the weir. Thus, if a given liquid level is desired with a given liquid load flowing across the plate, the level can be maintained by a long, high weir or by a low, short weir. In general, bubble cap plates are designed to operate so that the liquid level on the plates is 0.5 to 1.5 in. above the slots of the bubble caps (based on no froth). It is good practice to remove the liquid from the plates under low weir heads, since this prevents large variations in liquid level with considerable variations in liquid flow.

Weirs are usually of two types, (1) circular pipes extending through the plate to the plate below, the edge of the pipe serving as a weir, and (2) flat plates extending across the chord of the column circle (chord type weirs). Typical circular weir installations are illustrated in Figs. 5 and 6, and chord type weirs in Figs. 7 and 8. In some cases, the downspout may be formed by the extension of the chord type weir below the plate. Where frothy liquids are encountered it is advisable to provide disengaging space between the weir and the downspout as shown in Fig. 7.

At low flow rates, where there is ample downspout capacity, the liquid flows over the weir at a low head and passes down the walls of the downspouts as a film. The downspout is largely empty of liquid except for the liquid seal at the bottom of the



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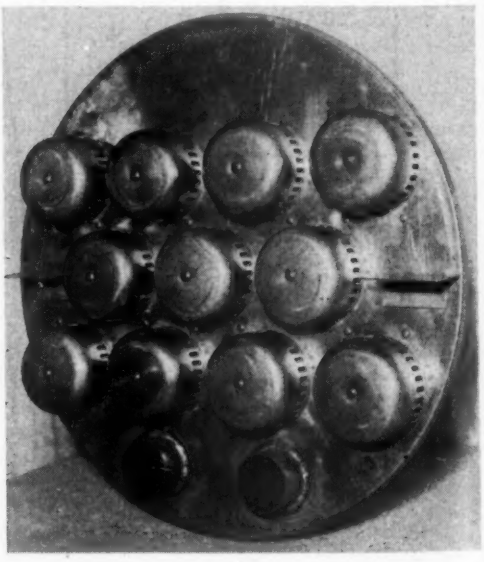

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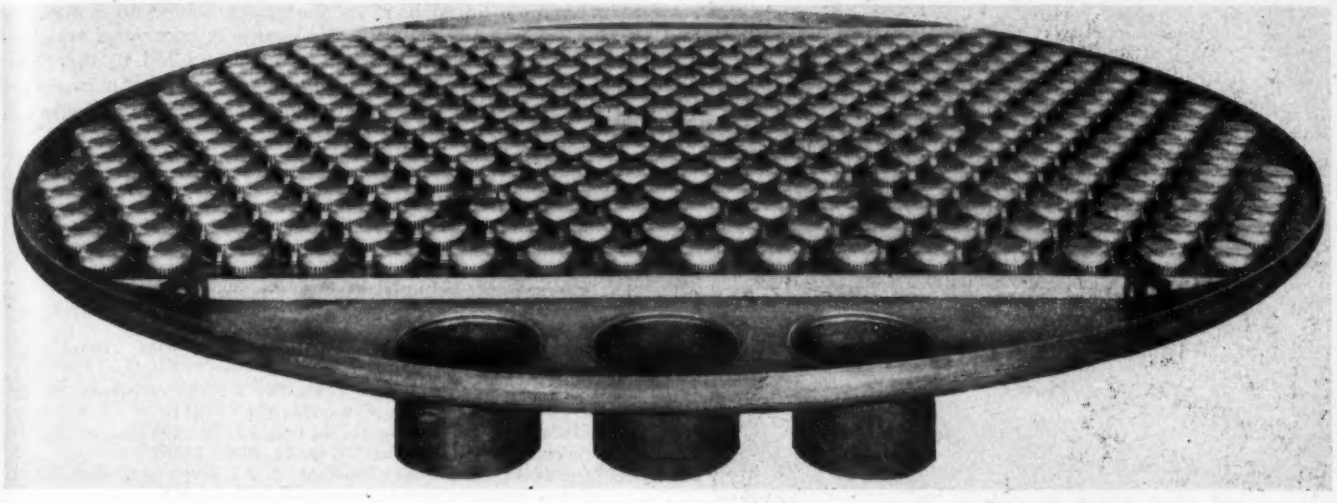
Figs. 5 (left) and 6 (above)—Typical circular weir installations



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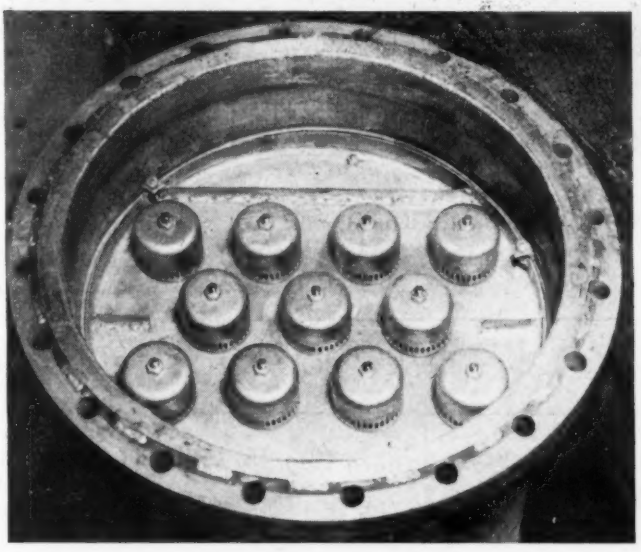
Figs. 7 (above) and 8 (below)—Typical cord type weir installations



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downspout. In such cases the flow of liquid over the weir is computed by the Francis weir formula[2]

$$Q = 0.0067LH^{1.5} \quad \ldots\ldots (7)$$

where

Q = discharge in cu. ft. per sec.
L = length of weir, in.,
H = head above edge of weir in inches of flowing liquid.

This equation is applicable to circular weirs provided the diameter of the downspout is greater than four times the head of fluid over the weir. For circular weirs where the diameter is less than four times but greater than twice the head

$$Q = 0.00823D^{1.675}H^{0.825} \quad \ldots\ldots (8)$$

and where the diameter is less than twice the head

$$Q = 0.0065D^{2}H^{0.5} \quad \ldots\ldots (9)$$

Equation 7 may also be used for wedge type weirs provided the head over the weir does not exceed the average distance from the weir to the shell of the column. If the wedge type weir is relatively close to the wall of the column, the wall exerts a constricting effect on the flow which may be corrected for by the factor K, which is plotted as a function of dimensions in Fig. 9. The approximate head of liquid over the weir is calculated assuming that K equals 1.0 (no constricting effect). The maximum distance of the weir from the walls is evaluated from curve 1 of Fig. 9. The head of liquid over the weir is subtracted from this distance to give the effective maximum distance of the weir from the wall. This value is used to calculate the effective length of the weir. The correction factor is then evaluated from the ratio of the actual to the effective length of the weir by means of curve 2. The value of the correction factor so calculated is used in Equation 7 to calculate a new head of liquid over the weir. Usually this will be sufficiently close to the approximate value of the head that a recalculation of the correction factor is unnecessary.

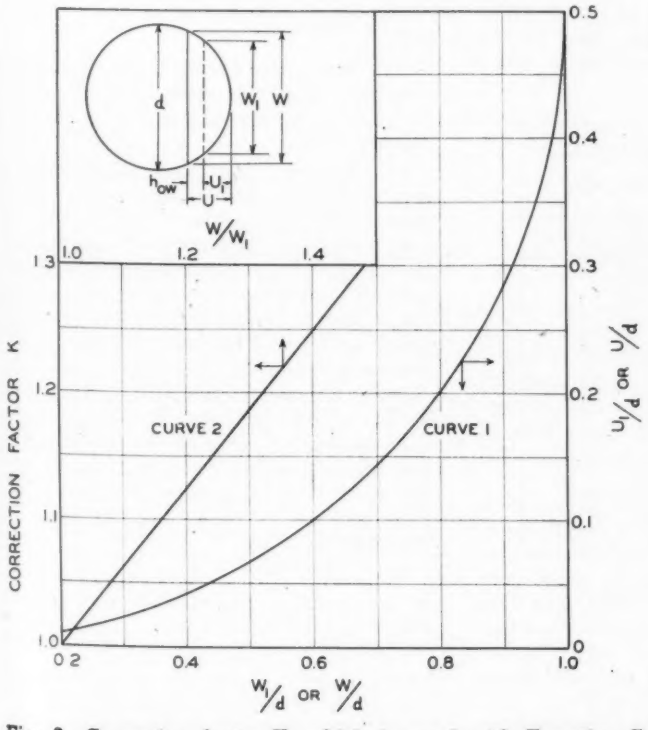

Fig. 9—Correction factor K, which is used with Equation 7 to allow for constricting effect on flow of a wedge type weir relatively close to the wall of a column

In many cases wedge type weirs are preferred to circular weirs since they produce more even distribution of liquid flow across the plates. With simple cross-flow plates, as shown in Figs. 5 through 8, the length of wedge type weirs is approximately 60 to 80% of the column diameter. In large columns where even distribution of liquid flow becomes especially important, V-notch or rectangular notch weirs with variable spacing may be used. When it is desirable to increase the length of a central weir on a radial flow weir, an irregular shape may be used as shown in Fig. 10.

The previous discussion has been concerned with weirs used

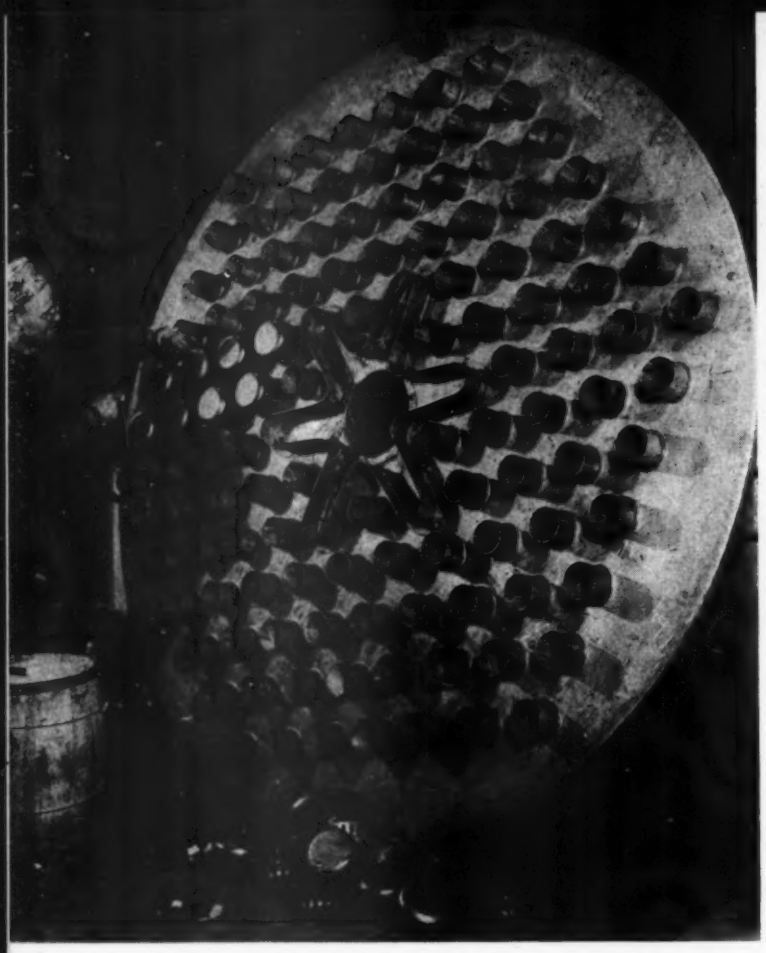

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Fig. 10—An irregular-shaped weir, used when it is desirable to increase the weir length

to maintain a liquid level on the plates. These are commonly known as exit weirs. Other weirs known as inlet weirs are often used to provide even distribution of liquid fed to the plate. Examples of these are shown in Figs. 7 and 8. An important function of these weirs is to prevent vapor from being discharged under the downspout.

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A knowledge of many variables is necessary for the efficient management of a lease. The subjects discussed in the book include the maximum efficient rate of production (the MER), uniform rates of production and depletion, economic limits for wells and reservoirs, increasing and decreasing rates of depletion, interest factors, and the like.

The present volume is a continuation of a presentation of the mechanics of production contained in Vol. I. Author Jones is a consulting engineer in Houston.

New Diesel Engine Manual Will Help Maintenance Men

Diesel Operation and Maintenance, by Orville L. Adams, Sr.; 6 x 9 in., 366 pages, stiff cloth binding, illustrated, indexed, $5.00.

Petroleum maintenance men should find this new volume helpful in their daily tasks of keeping power units in running order.

Diesel Operation and Maintenance places considerable emphasis on the fundamental aspects of Diesel engineering operating problems. It identifies the origin of all major difficulties and ties the solution in with the fundamental principles. It covers standard accepted repair procedures coupled with standard inspection methods. Guides to trouble-shooting contain instructions on diagnosis of fuel oil and lubricating problems, determining the cause of engine failures, and breakage of engine parts. Numerous questions and problems follow each chapter to help bring out the salient points presented.

The author, O. L. Adams, was formerly research engineer with Guiberson Diesel Engine Co., Dallas, is a Lieutenant Commander in the U. S. Naval Reserve, and a member of American Society of Mechanical Engineers, Society of Automotive Engineers, American Society for Engineering Education, United States Naval Institute, and the Army Ordnance Association.

Latest Edition of National Electrical Codes Available

National Electrical Code, Vol. V. of National Fire Codes; 6 x 9 in., 408 pages, stiff cloth binding, indexed, $2.00; 1947.

The newest edition of the *National Electric Code* supersedes the 1940 edition and interim amendments, and was adopted by the National Fire Protection Association at its 1946 annual meeting. It was also approved by the American Standards Association in October, 1946.

Included in the back of the book are 31 pages of advertisements by manufacturers of electrical equipment which should be helpful to electrical men using the code.

Helpful Trade Literature

The Turner-Burrell Adsorption Fractionator, Bulletin No. 205, a 10-page booklet discussing adsorption fractionation and presenting a description of the apparatus, its utilization and operation. Burrell Technical Supply Co., 1936-42 Fifth Avenue, Pittsburgh 19, Penna.

Equipment and Materials for conditioning Water and Other Liquids (Catalog G), describes different types of water conditioning processes, with applications, advantages and limitations of each. Includes tables listing different kinds of gaseous and solid impurities, chemical reactions in various water softening processes, and factors for converting ppm of various compounds to ppm of $CaCO_3$. Liquid Conditioning Corp., 423 West 126th St., New York 27.

The Co-ordination of Motive, Men and Money in Industrial Research, a 64 page handbook covering the origins of science, technical research and laboratories, industrial research motives, general organization, management guides for executives and key personnel, and the provision of funds and their control. Based on a survey of a number of leading petroleum and chemical companies. Extensive organization charts. Standard Oil Co. of California, 225 Bush Street, San Francisco, California.

Correction

Wyatt's, the 216-page book depicting pictorially the broad range of products of that company, and reviewed on these pages in the January issue of PETROLEUM PROCESSING, is available for limited distribution at a price of $10 per copy. This price quotation was omitted from the review last month.

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Researches were carried out under the direction of Dr. K. M. Watson, Professor of Chemical Engineering at the University of Wisconsin, and his associates.

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Data from the literature for the pyrolysis of propane and its products are analyzed and rate equations developed for ten reactions which contribute significantly in determining the rate and product distribution in this operation.

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Toluene from Benzene plus Xylenes

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Chemical Feeds for New Water Conditioner Electrically Operated, Centrally Controlled

By C. E. JOOS
Cochrane Corporation
Philadelphia, Pa.

TO PROVIDE suitable feed water for the high-pressure boiler plant now being expanded at its Philadelphia refinery, Atlantic Refining Co. is installing new conditioning equipment capable of handling 50,000 gal. of water per hour. All feeds for chemicals used in the conditioning process are electrically operated, and all controls are located on a central panel-board.

The equipment includes a two-stage type of deaerating hot process softener. Treatment is with lime and soda ash in the first stage (followed by deaeration), and phosphoric acid in the second stage.

Raw feed water at Atlantic's Philadelphia refinery is taken from the adjacent Schuylkill River, and has a hardness that may vary from 8 to 20 grains per gallon. In addition to the hardness, this stream is contaminated with silt, organic material, oil and industrial wastes, so that the chemical treatment in conditioning the water for high-pressure boilers must be executed very carefully in apparatus of proper design.

The petroleum industry has been quick to adopt the economies of high-pressure boilers, which make it possible for an industrial plant to obtain byproduct power at a very low cost. Many refineries have installed high-pressure boilers ranging up to 600 psi pressure, and some are even contemplating pressures as high as 1500 psi. But to realize the full economy of such equipment, strict attention must be paid to the quality of feed water used.

Results Required of Water Treatment

Generally speaking, the principal characteristics desired in a feed water for high-pressure boilers may be enumerated as follows:

(1) Low residual hardness, with zero as the goal. The reason for this is that any residual hardness will form a sludge, and possibly scale, on concentration in the boiler. In addition to the insulating effect of this sludge and the necessity of cleaning, it may also be conducive to foaming and priming characteristics.

(2) Low silica concentration. While silica is not of major importance with low-pressure boilers, it is one of the prime objectionable constituents of feed water for high-pressure high-rating boilers from two standpoints. The high silica concentration may cause adhering scale deposits, but, more particularly, may be carried over with the steam and cause turbine-blade deposits with loss in capacity and efficiency. Expensive cleaning for removal of silica deposits from the blades may ultimately result.

(3) Low residual alkalinities. The concentration of caustic soda, sodium carbonate, and phosphate must be maintained at low limits in order to prevent foaming and priming characteristics.

(4) Reduction of organic matter. Presence of these foreign solids induces foaming and priming characteristics.

(5) Low concentration of solids. Excessive solids result in exorbitant blowdown to waste.

In order to achieve these objectives with a water supply so badly contaminated as the Schuylkill River, the Atlantic Refining Co. has installed a 50,000 gph Cochrane deaerating hot process softener of rather unique design in accordance with a method of treatment recommended by the C. W. Rice Co. The installation was selected on the basis of the performance of a hot process softener that has been in operation for the past five years.

Lime and Soda Ash Hot Process Softeners

The general layout of the plant is illustrated by the flow diagram given in Fig. 1. Water is taken directly from the river, and after passing through condenser boxes is delivered to the hot process softener where it is treated with reagents of lime and soda ash. After heating of the water to within 2-3° F. of the steam temperature and the addition of chemicals, the water is allowed to settle for one hour in its passage through the sedimentation tank in order to per-

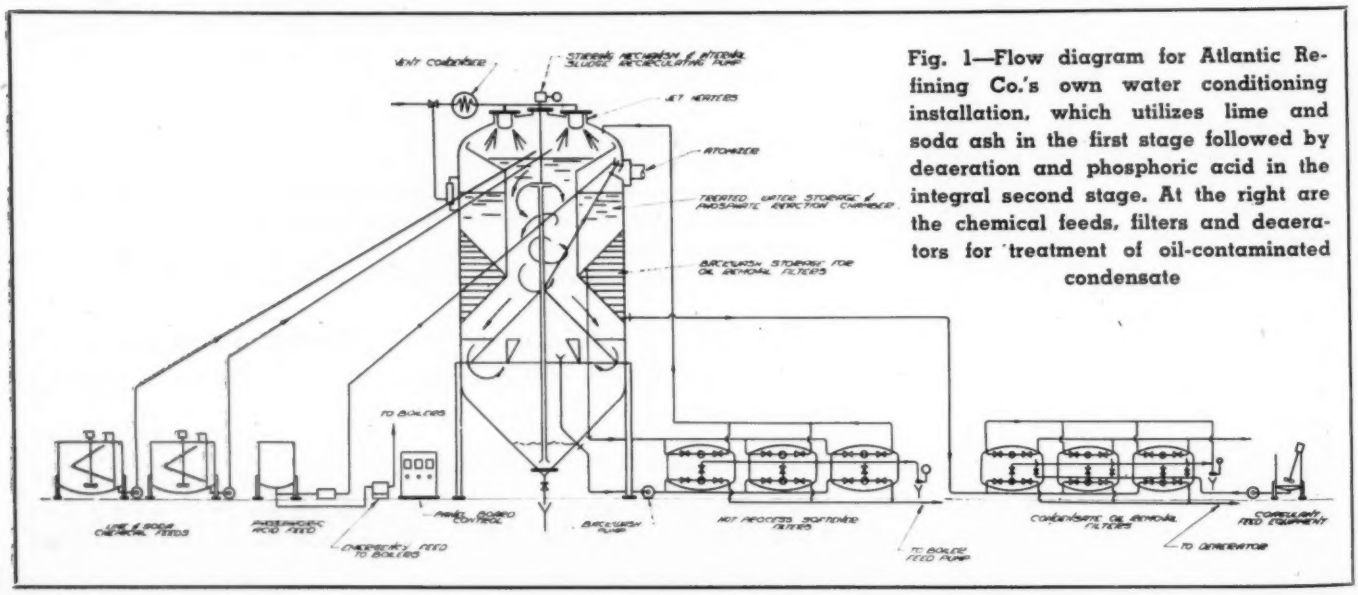

Fig. 1—Flow diagram for Atlantic Refining Co.'s own water conditioning installation, which utilizes lime and soda ash in the first stage followed by deaeration and phosphoric acid in the integral second stage. At the right are the chemical feeds, filters and deaerators for treatment of oil-contaminated condensate

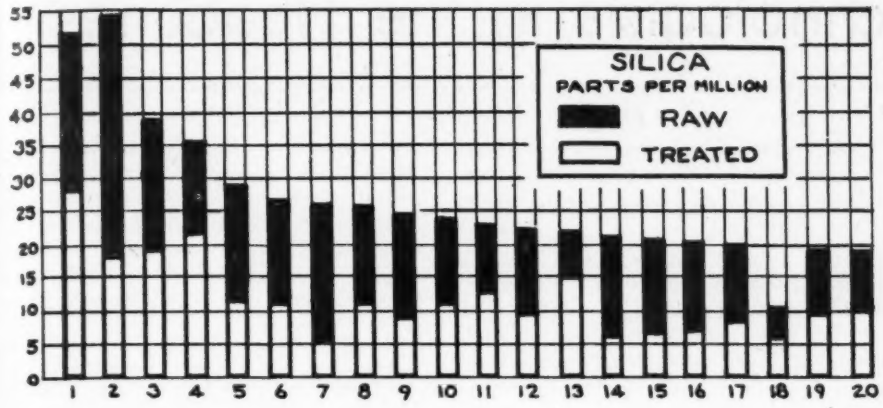

Fig. 2—Reduction of silica in 20 typical cases accomplished by lime and soda ash, utilizing only magnesium hardness in precipitate as silica coagulant

mit growth of the precipitated particles, and insure complete precipitation.

The lime and soda treatment accomplishes a number of objectives:

(1) It precipitates the hardness down to the order of 15 ppm.

(2) The organic matter will be reduced by approximately 30% to 50%.

(3) The suspended matter and silt will be coagulated by the precipitated hardness, reducing the turbidity to low quantities.

(4) The precipitation of the magnesium hardness in the water will absorb some of the silica, reducing this objectionable constituent to a low value.

Fig. 2 indicates the amount of silica reduction in a number of tests utilizing only the magnesium hardness of the water as a precipitant.

In addition to this treatment there is also provided a means of recirculating sludge to the extent of approximately 2% of the inflow, which increases the efficiency of silica reduction and also greatly assists in coagulation of precipitated hardness and the suspended matter.

Deaeration

From the primary sedimentation tank the water is then delivered to an atomizing type of deaerator in which the treated water is distributed over a high velocity steam jet caused by the flow of the heating steam through a special design of atomizing valve. This atomizer, operating on the same principle as a steam atomizing oil-burner, breaks up the makeup water to very fine particles, thus permitting the escape of residual oxygen from the hot process preheating equipment. The oxygen is actually reduced to zero as determined by the standard Winkler test procedure.

Second State of Softening

Following the deaeration process the water is delivered to an annular compartment built into the sedimentation tank, at which point phosphoric acid is added. The phosphoric acid will react with the residual hardness, reducing this to zero. This compartment provides for a retention time of 45 minutes.

Following the second stage of softening the water is then filtered through five pressure filters where the last vestige of turbidity is removed. From that point the makeup water is delivered to the boilers. The makeup water will be crystal-clear, have a hardness of zero, comparatively low alkalinity, low silica concentration, and low organic matter.

The filters are cleaned by taking heated and softened water from the sedimentation tank and returning it thereto.

Treatment of Contaminated Condensate

The condensate available at the plant is contaminated with oil and this is first coagulated by the use of aluminum sulphate and alkalinity. The precipitated aluminum hydroxide is prepared externally to the filters and then delivered as a floc to the filters. This is sufficient to remove the oil from the condensate. Clear condensate is then delivered to the existing deaerating heater for deaeration. Following the process of deaeration the condensate will be delivered to the suction of the boiler feed pump.

Improvements in Hot Process System

The hot process water softener had its beginning at the turn of the century. Soda ash was fed into an over-sized open feed water heater to bring about partial precipitation of hardness. The feeding of lime in addition to soda ash was adopted in 1912, and these became the standard reagents.

Many mechanical improvements have been incorporated in the apparatus in the past several years. These have led to increased efficiency and lower cost of the equipment, maintenance and operation.

Deaerating apparatus has been incorporated as part of the unit, eliminating the necessity of installing separate equipment for this purpose. This design was made possible by the development of a new means of deaeration employing the principle of dividing the preheated water into a very fine mist by a high velocity steam jet.

The development of a stirring device has aided in improved flocculation by bringing about an intimate mixture of chemicals and agglomerating the resulting precipitates. As shown in Fig. 3, the optimum speed of rotation for the stirring mechanism is quite pronounced in its effect upon the amount of suspended matter in the effluent. With proper speed, turbidity may be reduced from 25 ppm to 5 ppm, although increased speeds beyond the critical point result in increased turbulence and improper sedimentation.

Electrically operated chemical feeds have been incorporated to simplify the regulation of chemicals for the operating engineers. Means of recirculating sludge have been incorporated in order to bring about more intimate contact of the magnesium precipitates with the water for the reduction of silica. This recirculation of sludge can likewise be arranged for automatic operation in proportion to the flow of makeup water.

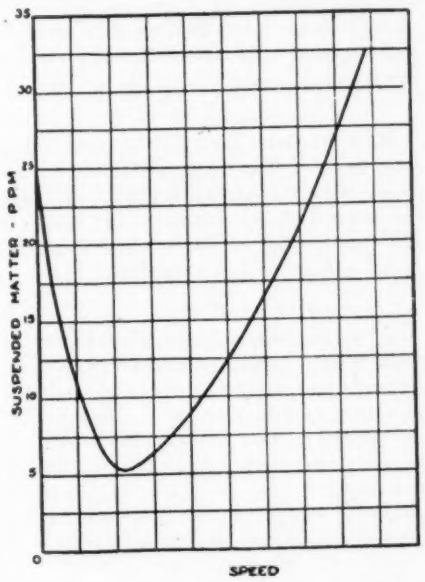

Fig. 3—Relationship between speed of the stirring mechanism used in mixing treating chemicals and the amount of suspended matter in the effluent. The optimum point varies from 2 to 10-12 rpm, depending on tank diameter, rotating vane length and width, etc. Actual design is based on past practice experience

PERSONALS

Petroleum Technologists in the Headlines

Dr. L. A. Mikeska of the chemical division of Standard Oil Development Co. has been appointed senior research associate. The new title, which will also be given to others who merit it, is to establish a system to give greater recognition to noteworthy technical achievements by the staff of Standard Oil Development Co., **E. V. Murphree,** executive vice president in charge of research, said.

Dr. Mikeska

Dr. Mikeska received the title award for his work on the structure of hydrocarbons. He has been with the company since Feb. 1930. Most of that time he has worked on the chemical structure of lubricating oils. Since 1940, when Dr. Mikeska undertook a new assignment—research on wetting agents, detergents for textiles and lubricating oil additives—the API has carried on that work, with Dr. Mikeska acting as an adviser.

He was graduated from the University of Texas with a B. A. in chemistry and mathematics in 1913, and an M. A. in chemistry in 1914. He received his Doctor's degree at Yale in 1917, remained there as an instructor for several months, and also taught briefly at Tulane.

• • •

H. A. Mason, General Petroleum Corp., Los Angeles, has been promoted to asistant manager of the laboratories. He has been with the company for 30 years and will make his headquarters at the home office in Los Angeles.

• • •

A. J. Ferguson, Standard Oil Co. of New Jersey, Louisiana division, has been shifted from safety engineer to assistant head of maintenance and construction, as part of the company's policy to broaden the experience of supervisory personnel. He is being replaced as safety engineer by **Ed Stauverman, Jr.,** who was assistant safety engineer.

• • •

Rodger L. Cuthbert, formerly an engineer for Gulf Oil Corp., is now junior chemical engineer at the rubber chemical plant of the B. F. Goodrich Chemical Co., at Akron, Ohio.

• • •

H. P. Sumpter, for the past three years assistant chief chemist at the Neches Butane Products Co., has returned to his parent company, Socony-Vacuum, and is now with the light products division of the research and development laboratories, Paulsboro, N. J.

• • •

Fred Lister, recently with the Institute of Gas Technology, has joined the staff of the Tide Water Associated Oil Co., Bayonne, N. J., as a research chemist.

• • •

Charles C. Cerato is now associated with the experimental division of the Sun Oil Co., Norwood, Pa. He is working on Raman absorption spectroscopy. Mr. Cerato was formerly with Spectrographic Services and Supplies Co.

• • •

H. W. Harts, vice president of Warren Petroleum Corp., Tulsa, is to head the 1947 Convention Program Committee of the Natural Gasoline Association of America convention to be held April 23-25 in the Baker Hotel, Dallas.

Mr. Harts

Other appointments to the Committee, made by NGAA president **J. H. Dunn,** Shamrock Oil and Gas Corp., Amarillo, are; **W. L. Bowser,** Atlantic Refining Co., **F. B. Haverfield,** Continental Oil Co., **Max Lents,** J. S. Abercrombie Co., **James E. Pew,** Sun Oil Co., **W. H. Vaughn,** Tidewater Associated Oil Co., and **C. R. Williams,** Chicago Corp.

President Dunn stated that elaborate plans for the coming NGAA convention have already been made and the reports and papers presented at the technical sessions should be of particular interest to both the natural gasoline and cycling industrialists whose studies and reports have been curtailed till now because of the general war effort.

• • •

Anderson W. Taylor has been appointed superintendent, light oil division, Ponca City refinery of Continental Oil Co. He was succeeded by **Lawrence S. Burke** as assistant superintendent, Glenrock refinery.

• • •

Robert M. Shepardson has been appointed associate manager of Standard Oil Development Co.'s process division. He formerly was an assistant manager.

• • •

Recent additions to the staff of the Wood River research laboratories of the Shell Oil Co., Wood River, Ill., are **F. Wopat, Jr.,** University of Wisconsin; **H. A. Poitz,** Colorado School of Mines; **H. R. Mullin,** Georgetown University; **J. E. Douglas,** University of Western Ontario; **R. W. Cloyd,** University of Michigan; **E. M. Bens** and **W. J. Koph,** Iowa State College; and **R. E. Hoy,** St. Vincents College.

• • •

Joseph E. Bludworth, for several years director of petroleum chemicals research and development for the Celanese Corp. of America, has opened offices in the Nixon Bldg., Corpus Christi, as a consulting engineer to the petroleum and chemical industry.

Mr. Bludworth

Associated with Celanese since 1934, Bludworth went to Corpus Christi in 1943 when ground was broken for the Celanese Chemcel plant at Bishop, Texas. A native of Flatonia, Texas, he began his petroleum career with the old firm of Chestnut and Smith (now part of the Lone Star Gas Co.), where he helped develop the first high pressure natural gasoline refining technique. He was a consultant at Arlington before joining Celanese.

• • •

Wayne J. Faust, recently discharged from the Army has joined the chemical engineering staff of Universal Oil Products Co., Riverside, Ill.

• • •

Thomas L. Upjohn has been promoted to supervisor of the Light Products Division, Socony-Vacuum Oil Co., Paulsboro, N. J. He was assistant to the director of the division in New York.

Annual Index Ready

The annual index of articles published during 1946 in PETROLEUM PROCESSING (Sept.-Dec.) and the NPN *Technical Section* (Jan.-Aug.), its predecessor, is now ready. It gives a complete subject and author listing of all material appearing during the year in the two magazines. Copies of the index can be obtained, without charge, upon request to:

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W. G. **Ainsley**, Sinclair Refining Co., has been named as one of the eight members of the Society of Automotive Engineers' Technical Board for 1947. His appointment is for three years in accordance with SAE regulations.

° ° °

C. H. **Haynes**, superintendent of refining and oil movement, Standard of New Jersey, Louisiana division, has been named to coordinate the tank farm and dock operations of the company.

° ° °

J. M. **Jennings**, assistant process superintendent for Standard of New Jersey's Louisiana division has been promoted to superintendent of refining and oil movement of that division.

° ° °

J. N. **MacKendrick** has been elected vice president in charge of engineering of Clark Bros. Co., Inc., Olean, N. Y. He came to the company in 1929 as engine designer and after serving in that capacity for 7 years became chief engineer.

° ° °

H. G. **Mangelsdorf** has been named general superintendent of the petroleum-products division for the Standard Oil Co. of New Jersey, Louisiana division. He was promoted to his present position from manager of the chemical-products division.

R. J. **Stone** has been named assistant to the general manager of Standard Oil Co. of New Jersey, Louisiana division. He succeeds J. P. **Warner**, who was made head of the chemical-products division. Mr. Stone is general superintendent of the petroleum-products division.

° ° °

J. D. **Bartleson**, Standard Oil Co., (Ohio), was renamed 1947 chairman of the petroleum section of the Cleveland Chapter of the American Chemical Society at its January meeting.

John V. Kalb has been promoted from mechanical engineer to lubrication engineer by The Texas Co., New York City.

° ° °

Until recently an engineer with the American Standards Assn., **Frederic R. Speed** has been appointed a lubricants and fuels technologist of the Procurement Bureau of the U. S. Treasury, Washington, D. C. During the recent War he was a consultant with the War Production Board.

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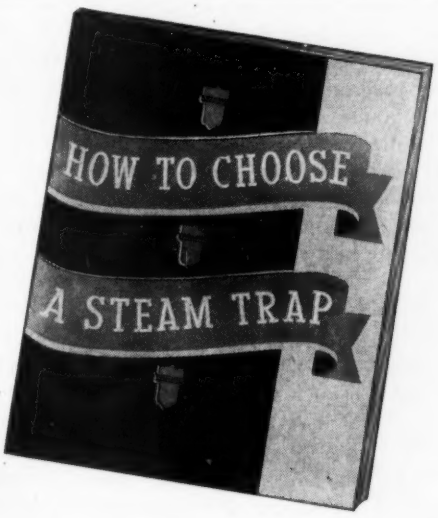

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WIDENING HORIZONS

Views on Personnel, Management and Economic as Well as Technological Developments in Petroleum Refining and Natural Gas Processing: Comment from Readers is Invited

Shall Government Permanently Engage in Liquid Fuels Research?

THE proposal now in a bill before Congress to extend the Bureau of Mines Synthetic Liquid Fuels program for three years beyond the original period, and to appropriate $30,000,000 more for the work, raises the issue as to whether this government agency shall permanently engage in this field of research. (See pg. 85.)

In the recent report on the program made by the Secretary of the Interior there is no reference as to completing the task for which Congress originally assigned five years. Before an additional three years is up, more permanent buildings will be added to the project, their staffs enlarged and new avenues for further research will be enticing the government scientists. The arguments for continuing the program which are being advanced now can be even more convincingly presented when the proposal comes up again. So it would seem that the issue to be considered is whether the government is to permanently engage in a field of research in which the oil companies are now conducting much work.

When the Synthetic Liquid Fuels program was originally approved by Congress it appeared that the war might continue for some years. The preamble to the bill stated the proposed study into sources for substitute fuels would aid in the prosecution of the war. At present the need for synthetic fuels from coal and shale is in the distant future and the oil companies themselves are now deeply engaged in certain phases of research into synthetic fuels. In fact, the technological improvements they have reported to date are more significant than anything the Bureau of Mines has thus far turned up in its own project.

In reviewing the Synthetic Liquid Fuels program for even the remainder of the original term, until 1949, we believe Congress should ask that the funds it appropriates be spent on research of a nature that will not duplicate what the oil companies are doing. A good part of the $30,000,000 to be appropriated for the original five years of the program is being spent on studies in the fundamental principles of hydrocarbon chemistry and in processing techniques which the oil companies have carried on for many years, and which they are better equipped to do than the Bureau of Mines.

There is one type of research work, however, which this governmental agency by nature is better fitted to carry on than the oil companies.

The low grade coal deposits and the oil shale beds of the country could be minutely assayed and analyzed for their potential value as source material for synthetic fuels when and if needed. The use of either of these raw materials in the commercial scale production of substitute fuels, will call for excavating, conveying and handling solid materials, and in the case of shale, disposal of solid wastes, on a tremendous scale. Studies of methods to be applied here and the economics involved are beyond the scope of research and development work of any individual oil company.

At present such work is only a small part of the Bureau' program but it could be expanded and emphasized. It would correlate, but not duplicate, the studies of actual processing techniques which some of the oil companies have been engaged in for several years.

Such phases of the Bureau's Synthetic Liquid Fuels program could be completed without calling for $30,000,000 more of the taxpayers' money.

Science Replacing Witchcraft In Engine and Fuel Testing

THE year 1946 should go down in history as a milestone in the long and arduous work of developing suitable test methods for automotive engine-fuel relationships, because of two important developments.

1—Making generally available primary reference fuels, the use of which in actual laboratory and road testing eliminates a source for many of the inaccuracies and correlation difficulties in test work in the past.

2—Application of scientific instruments for indicating engine knocking, which are practical for test work in that they can be installed in a short time on either laboratory or road test engines and are relatively simple to operate. They replace the human ear as the means for detecting and measuring engine knocking. Their greater accuracy is hardly open to question.

Both these achievements have been long in the making. Their significance was emphasized in papers and discussions at the recent annual meeting of the Society of Automotive Engineers. The importance of the new development in the primary reference fuels, iso-octane and normal heptane, lies in the fact they can now be bought by testing agencies at a price of $1 a gallon. Two oil companies, Phillips Petroleum Co. and Standard Oil Co. of New Jersey, worked out economical methods to make these hydrocarbons, to a degree of purity of 99% plus as certified by the Bureau of Standards, so they can be sold at this relatively low cost.

These primary test fuels used to cost $15 a gallon as supplied by a few chemical concerns. At these previous prices, much of the actual test work with engines was done with so-called secondary reference fuels, made up in the individual laboratory. The chemically pure primary fuels were kept on the shelf and used chiefly in calibrating and checking the secondary fuels.

In addition to providing much greater accuracy than the human ear in registering engine knocking, scientific instruments make possible studies in engines and fuels that heretofore could not be undertaken. With instruments it can be determined which cylinder, or cylinders, are knocking; engine vibration due to other causes can be analyzed.

Either one of the above achievements is significant in the long and tedious course of development of engine and fuel testing methods. Taken together, however, they mark the start of a period when more rapid advances can be expected in bringing engine requirements and fuel quality into close relationship. The public will ultimately benefit through having cars with both better engine performance and greater fuel economy.

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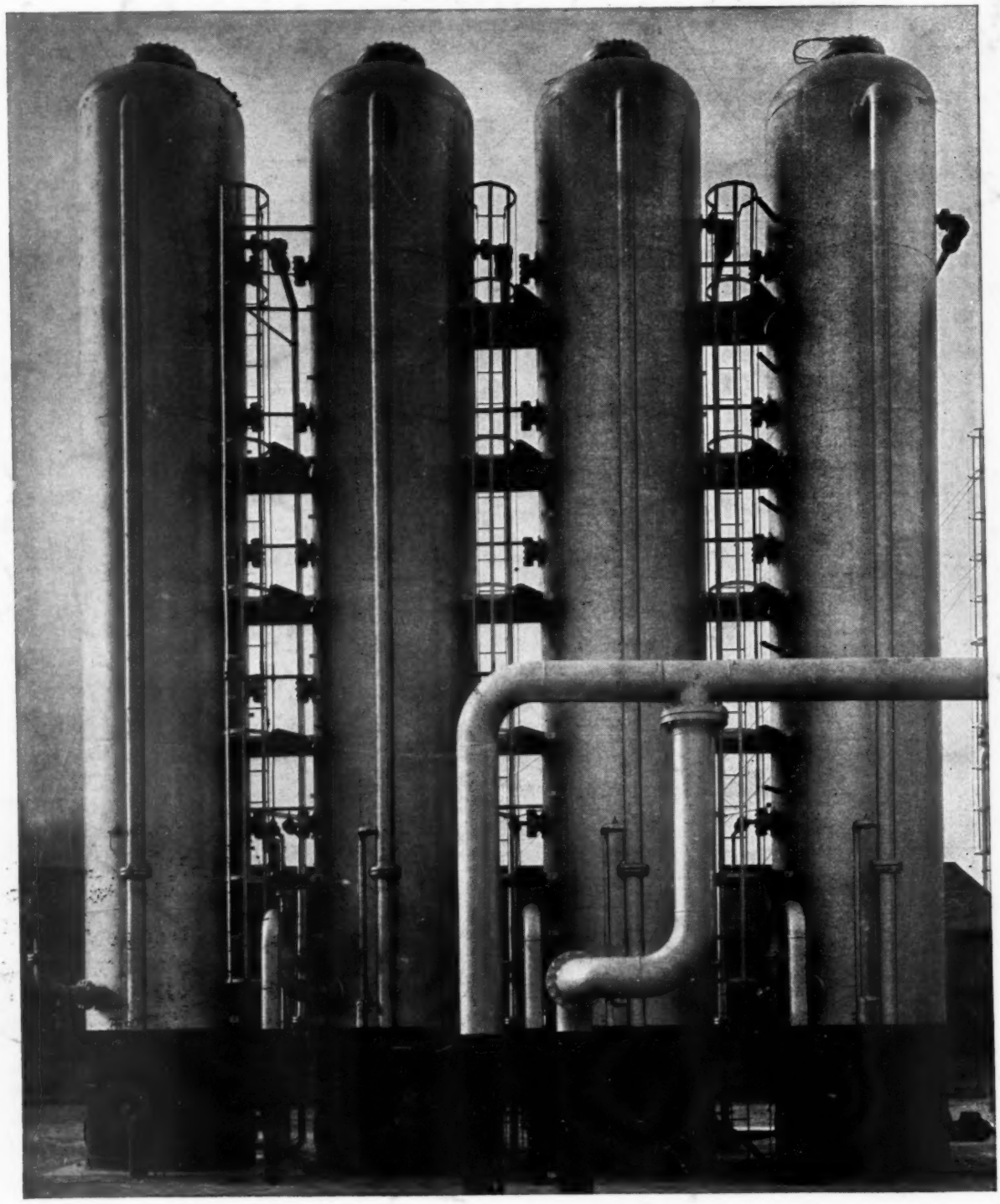

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